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ORIGINAL ARTICLES.

I.—Note on a Skeleton of a Young Plesiosaur from the Oxford Clay of Peterborough.

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(PLATE IX.)

ONE of the most notable additions made to the Gallery of Fossil Reptilia in the Natural History Museum during the last few years is the beautifully preserved Plesiosaurian skeleton which is represented in Plate IX.

This specimen was obtained by A. N. Leeds, Esq., of Eyebury, near Peterborough, from a pit in the Oxford Clay at Fletton, in the neighbourhood of that town, and is a splendid example of the results obtainable by a careful collector who is able and willing to devote time and energy to personally superintending the removal from the deposits in which they are found of those specimens brought to his notice. The neglect of ordinary precautions has led to the loss or separation of too many valuable associated series of bones for it to be necessary to insist on the extreme value of such careful work as that of Mr. Leeds, to whom we are indebted for one of the finest collections of Mesozoic reptiles and fishes ever made.

In the present specimen (Leeds Coll., No. 36) the bones are quite uncrushed and free from matrix, and, though some of the more delicate ones were found broken into numerous fragments, it has been possible in most cases to piece them together, every fragment having been carefully preserved and numbered. The skull, owing to the fragile nature of many of its constituent bones, is, unfortunately, much broken and is imperfect, but the rest of the skeleton is complete, with the exception of some caudal vertebræ and chevrons, a few ribs, and some small paddle-bones. The whole has been skilfully mounted by Mr. C. Barlow, and now presents the appearance shown in Plate IX.

For reasons given in a recent paper[1] I consider that this skeleton is that of a young individual of *Cryptoclidus Oxoniensis*, Phillips, sp. A short description of the chief osteological characters exhibited by this specimen may now be given:—

[1] Ann. Mag. Nat. Hist. ser. 6, vol. xv (1895), p. 333.

The skull is comparatively short, the snout being blunt and rounded; its length is about one-third that of the neck. The premaxillæ, which are covered with irregular ridges, each bore five or six slender teeth, the crowns of which are nearly smooth.

The pineal foramen is large, and is situated between the anterior ends of the parietals. These bones form a high crest between the temporal fossæ, and posteriorly are produced outwards into short processes which unite with the ascending rami of the triradiate squamosals, the ventral rami of which unite closely with the quadrate, while the anterior, wanting in this specimen, formed the hinder portion of the temporal arcade. These squamosals are very like the same elements in *Sphenodon*, and probably are equivalent to squamosal+supratemporal.

The *basioccipital*, which is still free from the basisphenoid, bears the whole of the nearly hemispherical occipital condyle. The *basisphenoid* is deeply excavated anteriorly by the pituitary fossa, and has adherent to its ventral surface a plate of bone which is prolonged anteriorly. This element, which must be regarded as a *parasphenoid*, is well shown in some Pliosaur skulls in the British Museum, in which it runs forward for some distance between the pterygoids which unite with its outer edges.

On the outer side of the exoccipitals, and when seen from the outer surface of the skull, apparently arising from those elements, are the large paroccipital processes which are directed outwards and downwards. If this region be examined on the internal surface, it is seen that these processes spring from distinct elements (the *opisthotics*), still separated from the exoccipitals by deep clefts, although externally the sutures are obliterated. The opisthotic shows the impression of two of the semicircular canals. The *supra-occipital*, which is very large, is also channelled by a portion of the auditory labyrinth, there being no trace of a distinct epiotic ossification.

The mandible seems to have carried from 20 to 22 teeth; each ramus is about 23 centimetres in length.

The cervical vertebræ are 31 or 32 in number; the neural arches and cervical ribs are all free from the centra, a character depending merely on the age of the individual; the centra are short with oval articular faces, which are much less concave than in the adult; the neural spines are short and stout, and the anterior and posterior zygapophyses are respectively slightly concave and convex transversely; there is also a zygosphenal articulation.

No union has yet taken place between the centrum of the axis and that of the atlas (*i.e.* the odontoid); this latter bears the two halves of the atlantal neural arch, which are widely separated from the anterior wedge bone forming the lower fourth of the cup for the reception of the occipital condyle.

There are two or three pectoral and 21 or 22 dorsal vertebræ. Behind these are three or four vertebræ bearing short, somewhat expanded ribs, which articulate between arch and centrum; these appear to be sacral. The caudals bear small rib-like chevrons,

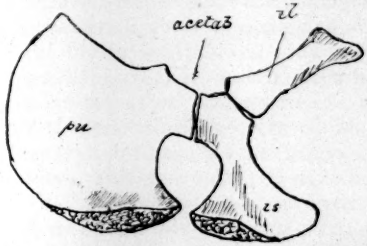
which do not unite below to close a hæmal canal and rarely fuse with the centra.

The abdominal ribs are strongly developed. They are arranged in several transverse rows, each consisting of a median piece and paired lateral pieces. In a former paper [1] I stated that there are two of these lateral pairs, and in the present specimen they are so mounted. In Mr. Leeds' collection, however, in a specimen [2] in which the ventral ribs are retained in their natural position through being partly imbedded in a hard concretionary mass of clay, there are clearly three lateral pairs, and this is also the case in, at least, some of the Liassic Plesiosaurs.

The pectoral-girdle has been figured and described in the paper just quoted.

The humerus at this stage shows scarcely any trace of the great distal expansion which characterizes it in the adult, but the radius is already very large compared to the other paddle-bones.

The ilium is a curved rod of bone, laterally compressed at its upper end and rounded at the lower, which in this specimen was evidently covered in life with a cap of cartilage, the articular surfaces not being ossified. In an adult ilium (see Figure) of the same species the lower end bears two articular surfaces—the larger



Pelvis of adult of *Cryptoclidus Oxoniensis* seen from within.
il, ilium; *pu*, pubis; *is*, ischium; *acetab*, acetabulum.

for union with the ischium, the smaller forming a portion of the hinder edge of the oval acetabulum; there is no surface for the pubis. The hatchet-shaped ischium has three subequal articular surfaces at its upper end, the posterior for the ilium, the median forming the middle and greater part of the acetabulum, and the anterior for the pubis. This latter is a broad plate of bone with convex anterior and concave posterior border; proximally it unites with the ischium and forms the anterior portion of the acetabulum.

The femur is rather less expanded distally than the humerus, a difference much more marked in the adult. The remainder of the hind-paddle calls for no special notice.

Plate IX. was prepared from a photograph taken by A. Gepp, Esq., of the British Museum (Natural History), to whom my cordial thanks are due.

[1] Ann. Mag. Nat. Hist. ser. 6, vol. xv (1895), p. 334.
[2] I am indebted to Mr. Leeds for drawing my attention to this specimen.

II.—On the Age of the World as depending on the Condition of the Interior.

By the Rev. O. Fisher, M.A., F.G.S.

IN *Nature* of the 7th of March, Lord Kelvin reported the results of a series of experiments, which render it almost certain that Prof. J. Perry's hypothesis of the conductivity of rock increasing with the temperature is unsupported by evidence. He also stated that he had been led by later study to modify his original estimate of the age of the world, and to reduce it to about the same as estimated by Mr. Clarence King, viz. 24 million years. Thus geologists would find themselves restricted to a still shorter period for the evolution of the events of the world's history than they supposed.

It must, nevertheless, be carefully remembered that the estimates of the world's age above referred to proceed upon the hypothesis that the earth is solid throughout, whereas the more obvious interpretation of geological phenomena appears to point to the opposite conclusion, that the crust is comparatively thin, and floats upon a substratum of molten rock of rather greater density than its own.

The principal argument for the solidity and rigidity of the earth is derived from the existence of tides in the oceans; for it is held that, if the interior were liquid, there would be subterranean tides in it, which would carry the crust and the enveloping ocean up and down in concert together, so that the measurable depth of the water to the bottom would always remain unchanged; for, although a tidal deformation of the ocean surface would be present, it would not be able to be noticed. It is plain that this apparent obliteration of the tides would require that the deformation in the substratum with its floating crust and the deformation in the enveloping ocean should occur at any given place simultaneously and equally; that is to say, there would have to be high tide in the crust where and when there was high tide in the water, and low tide in the crust where and when there was low tide in the water, and in each case with the same range of rise and fall. This requires that the surface of the crust should be deformed to the exact shape that the moon's attraction would produce in a liquid globe, and that the same should be the case also with the surface of the ocean. But, seeing that a tide is formed by the local accumulation of matter by differential horizontal flow, it seems highly improbable that the exact form of the tidal spheroid could be produced in the crust, because the irregularities in the under-surface of it, corresponding to and supporting the continental elevations, would so break up and deflect the tide wave in the substratum on which it floats, that the exact form of the tidal spheroid would not be generally maintained beneath the crust, just as it is known not to be maintained at the surface of the ocean owing to the deflection caused by coast lines, whence arise the irregularities known as the "establishments of ports." Thus the exact form of the tidal spheroid would be

maintained in neither crust nor water surface, and tides would accordingly be observed. If this be a correct explanation, it would seem likely that, where there is an exceptionally large unbroken area of ocean, and consequently a comparatively smooth extent of under-surface to the crust, in such a region the proper form of the tidal surface might be more nearly preserved both for the subjacent liquid rock and for the water, and the measurable tide would consequently be small. Now such is the case in the central parts of the Pacific, scarcely any proper tide being observable at the Sandwich Islands.

No argument for rigidity can be drawn from a fortnightly tide, because observations hitherto made have not demonstrated that one exists.

If the above apology for believing in the possibility of a liquid interior can be admitted, it will follow that, the bottom of the crust being constantly laved by molten rock, we should have a mode of communication of heat from beneath which would continually delay the cooling and thickening of the crust, and have an effect upon the temperature gradient at the surface similar to that which would have resulted from Professor Perry's hypothesis, supposing it to have been true.

If we accept Professor Darwin's theory of the genesis of the moon, there are cogent reasons for believing that interior liquidity is more than probable.

It seems to be admitted on all hands that the earth was once a molten spheroid, rotating at a speed much exceeding the present of once in twenty-four hours. The theory is, that at some early period the moon was thrown off from the earth, and that since that time its distance has gradually increased to the present 239,000 miles. This increase in the moon's distance, implying a large amount of work done in opposition to the earth's attraction, has been obtained at the expense of the energy of the earth's rotation, through the medium of tides produced in the earth and in the ocean, but chiefly in the earth itself. The leverage by which the moon has acted on the tidally deformed earth has necessarily been greater at the circumferential than at the central parts. Consequently the retardation of rotation has proceeded from without inwards, so that the inward parts have always rotated somewhat more rapidly than the outward, and a consequent friction and generation of heat has been set up within, which has been much more considerable in the central than in the outer parts. The amount of heat so generated would have been, to use Professor Darwin's own expression, "prodigious," and, upon his estimates, "the whole heat generated from first to last gives a supply of heat at the present rate of loss for 3560 million years." With this enormous amount of heat being perpetually communicated to the inner parts (and there does not appear to be any reason why the supply should have hitherto entirely ceased) how could the globe have become wholly solid at the melting temperature for the pressure at every depth? It seems that, having been once liquid,

it can never have had the chance of becoming sufficiently cool to solidify. If this be the true statement of the case, no reliable estimate of the age of the world, based on considerations of the present temperature gradient at the surface, has hitherto been made.

If the interior be liquid, and the central parts have been constantly receiving greater accessions of heat than the parts more distant from the centre, convection-currents must have been set up, and must have played the chief part in the secular cooling. The age of the world would therefore be dependent upon the degree of their activity, which is not known. Another important consequence would follow, because the currents would necessarily have a horizontal flow in the parts of their course where the liquid had ceased to rise and had not yet begun to descend; and this would produce a horizontal stress on the superincumbent crust, acting more powerfully upon it at those places where the bottom was most uneven, as beneath mountains. Thus we should be able to account for one cause, at least, of the compressing force for which geologists are in search.

Woodwardian Museum Notes.

III.—Supplementary Notes on the Drygill Shales.

By G. L. Elles and E. M. R. Wood, Newnham College, Cambridge.

In the Geological Magazine, 1887, Professor Nicholson and Mr. Marr drew attention to a group of fossiliferous shales detected in connection with the Borrowdale Volcanic Series.

At the request of Mr. Marr, we undertook the examination of larger collections of fossils made from the same locality, and the object of the following notes is to place these on record, and, in the light of further palæontological evidence, to assign to the beds a more definite horizon.

As Professor Nicholson and Mr. Marr showed, these beds occur on the north side of a great mass of Skiddaw Slates in what has been termed the Caldbeck Fells area. The shales to which we wish to direct attention are situated north of the intrusive masses of Carrock Pike and Great Lingy, and are of interest as lying between the Skiddaw Slates on the one hand, and the Volcanic Series of Caldbeck Fells on the other. They occupy the summit of the valley between High Pike and Carrock Pike, and are exposed in Drygill, whence Professor Nicholson and Mr. Marr have given to them the name of the Drygill Shales.

The following section is described by them in Drygill in descending order:—

1. Drab-coloured shales, unfossiliferous.
2. Blue-grey shales, weathering white.
3. Dark blue-grey or black mudstones.
4. Volcanic rocks.
5. Dark fossiliferous mudstones with Trilobites and Brachiopods.

The general dip of the beds is to the S.S.W., and the beds of the south fork of Drygill are probably the same as those exposed in the highest part of the main gill, since the faunas are almost identical,

and differ markedly from that belonging to the beds exposed in the lowest part of the same. The following is a complete list of the fossils as yet identified from the Drygill Shales, with their ranges. Many of the specimens have evidently been much affected by the mechanical deformation to which the rocks have been subjected; scarcely any of them are complete and many are very obscure.

TRILOBITA.

NAME.	REMARKS.	RANGE.
**Ampyx rostratus* (Sars.)	Common	Llandeilo—Bala.
Ampyx tetragonus (Angelin)		Bala (Trinucleus Schiefer of Sweden).
Ampyx tumidus (Forbes)		Bala.
**Stygina Murchisoniæ* (Murch.)	Common	Llandeilo—Bala.
Trinucleus seticornis (Hisinger)	Common	Bala.
Trinucleus concentricus (Eaton)	Common	Bala—Upper Llandovery (?)
Trinucleus, sp. (allied to *affinis*)		Bala (Trinucleus Schiefer).
Phacops (*Pterygometopus*) *alifrons*? (Salt.)		Bala.
Phacops (*Acaste*) *appendiculatus* (Salt.)		Bala.
Phacops, sp.		
Dindymene ornata (Linn.)		Bala (Trinucleus Schiefer).
Calymene Blumenbachii (Brong.)		Tremadoc—Aymestry (?)
Calymene senaria (Conrad)		Llandeilo—Wenlock.
**Calymene cambrensis* (Salt.)		Llandeilo—Bala.
**Lichas laciniatus* (Dalm.)		Bala (Brachiopod Schiefer).

OSTRACODA.

**Beyrichia complicata* (Salt.)		Llandeilo—Bala.

BRACHIOPODA.

**Obolella*?		
**Plectambonites sericea* (Sow.)		Llandeilo—Wenlock Shale.
Plectambonites transversalis (Wahl.)		Bala—Aymestry.
Plectambonites quinquecostata (M'Coy)		Llandeilo—Upper Llandovery.
**Orthis testudinaria* (Dalm.)	Very common	Llandeilo—Upper Llandovery.
Orthis elegantula (Dalm.)		Llandeilo—Upper Ludlow.
Lingula ovata (M'Coy)		Llandeilo—Bala.

LAMELLIBRANCHIATA.

Ctenodonta varicosa (Salt.)	Common	Bala.
Ctenodonta levata (Hall)		Bala.
Ctenodonta, sp.?		
Orthonota, sp.?		
Modiolopsis?		

GASTEROPODA.

Murchisonia, sp.		
Pleurotomaria turrita (Portl.)		Bala.
Pleurotomaria, sp.		
Bellerophon?		

CEPHALOPODA.

Orthoceras, sp.

* Denotes species previously recorded by Nicholson and Marr.

The fossils recorded above are by no means uniformly distributed

throughout the beds; the following were found only in the south fork of the gill, and the highest part of Drygill proper:—

Trinucleus seticornis.
Trinucleus concentricus.
Trinucleus, sp. (allied to *affinis*).
Phacops (*Pterygometopus*) *alifrons.*
Phacops (*Acaste*) *appendiculatus.*
Phacops, species.
Lingula ovata.

Calymene cambrensis and *Orthis testudinaria* do occur here, but are far more common in the lower part of the gill.

From the above lists it will be seen that the beds of the south fork, and of the upper part of Drygill, are characterized by the abundance of *Trinucleus*, while in the beds of the lower part of the gill species of *Ampyx, Stygina Murchisoniæ*, and *Orthis testudinaria* are very abundant.

It is obvious, therefore, that we have here two distinct faunas represented, and we would suggest that the beds in the south fork and upper part of Drygill belong definitely to a somewhat higher horizon than the beds exposed elsewhere in the stream.

Age of Drygill Shales.—Professor Nicholson and Mr. Marr (*loc. cit.*) suggested that there was a resemblance between the Drygill Shales and Dufton Shales, but considered that the abundance of such fossils as *Orthis testudinaria, Leptæna sericea, Calymene cambrensis, Ampyx rostratus*, and *Stygina Murchisoniæ* pointed to the beds being at about the horizon of the Llandeilo Limestone.

Species from Drygill Shales.	Coniston Limestone of Norber (Settle).	Dufton Shales.	Sleddale Group.	Quarrel Hill (Girvan).
Ampyx rostratus	x	...	...	x
Ampyx tetragonus	...	x	x	...
Ampyx tumidus	...	...	x	...
Trinucleus seticornis	x	x	x	x
Trinucleus concentricus	x	x	x	...
Calymene Blumenbachii	...	...	x	x
Calymene senaria	...	x	x	...
Lichas laciniatus	...	...	x	...
Plectambonites sericea	x	x	...	x
Plectambonites transversalis	x	x	x	...
Plectambonites quinquecostata	x	...	...	...
Orthis testudinaria	x	x	x	...
Orthis elegantula	x	...	x	x
Lingula ovata	...	x	x	...
Beyrichia complicata	x	...	x	...

They originally considered that the beds were younger than the Skiddaw Slates and older than the Coniston Limestone, but in a more recent paper (Geol. Mag. 1892) Mr. Marr expressed his belief that this correlation was erroneous, and that the Drygill Shales were probably more closely allied to the Coniston Limestone.

In the light of further palæontological evidence, we would emphatically confirm this suggestion. We believe that the beds lie above the Borrowdale Volcanic Series, and we are convinced that

they are most closely related to the Dufton Shales of the Cross Fell area, and to the Sleddale Beds of the Lake District proper.

Lithologically they do not differ more among themselves than do the Dufton Shales, which they resemble closely, since both are in the main composed of dark, flaggy, calcareous mudstones. The preceding table shows the species common to the Drygill Shales, Dufton Shales, the Sleddale Group, etc.

Summary.—The result then of our examination of the fossils of the Drygill Shales is to show the predominance of Bala Limestone forms, and the close parallelism of the beds with others of the same age in the Lake District.

Although correlated with the Bala Limestone as a whole, we think that the Drygill Shales are capable of further subdivision, viz. into (1) an Upper Group, characterized by the abundance of *Trinucleus*; (2) a Lower Group, characterized by the abundance of *Ampyx* and *Orthis testudinaria*, though it is not suggested that this subdivision is of more than local importance.

Note.—We take this opportunity of thanking Mr. Marr for many valuable suggestions, and of gratefully acknowledging the help given us by our friend Miss E. G. Skeat of Newnham College, in the identification of some of the fossils.

Our list of fossils was compiled from collections made at various times from Drygill, all of which are now in the Woodwardian Museum.

IV.—Shell-Structure in the Ammonoidea.

By Ernest H. L. Schwarz, A.R.C.S.
From the Geological Research Laboratory, Royal College of Science.

THE shell-structure of the Ammonoidea has received very inadequate attention from palæontologists; in most cases authors are content with describing the shell of the recent Nautilus, and saying that that of the Ammonites is exactly the same. Prof. Judd therefore suggested that I should take the subject up, when working as a research student under him. As a result, I have found that the resemblance of the Nautilus- to the Ammonite-shell is literally true; but the structure of the extinct forms throws an altogether new light on that of the recent one, while the usual homology of parts between the two requires, I think, revision.

In the Nautilus there are two main layers composing the walls of the shell: one nacreous and inner, the other porcellanous and outer. Of these, that corresponding to the inner layer is usually preserved in the Ammonoidea. In the Clymeniidæ, no details of shell-structure have been published; but in the Goniatites, Hyatt[1] has figured a *Gon.* (*Glyphroceras*) *crenistria*, Phill., from Rudesheim, showing the two layers, but both are probably parts of the same layer, since mineralization has destroyed the original structure.

In the Ammonites proper, the earliest example showing the original lustre and structure on record is *Ceratites nodosus*, de Haan,

[1] Bull. Mus. Comp. Zool. Cambridge, iii, 1852.

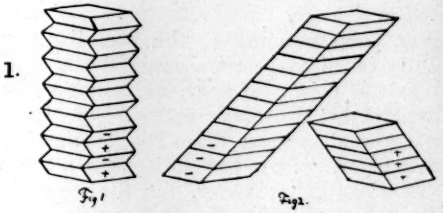
from Hanover.[1] In the later rocks innumerable cases occur in which the shells show their natural play of colour, such as the Oxford-clay Ammonites, *Am.* (*Psiloceras*) *planorbis*, Sow., from Watchet, or *Am.* (*Microceras*) *planicosta*, Sow., from the Marston Magna Marble of Wiltshire. Hyatt[2] has figured sections of the last with a short description, but he took the recent Nautilus as a key to the understanding of the parts, therefore I think it worth while to redescribe it with the help of a large series of sections of other Ammonites.

In the Ammonites and Nautili the inner layer appears to be composed of fine laminæ of calcium carbonate and conchiolin, alternating in varying thicknesses, but always very fine; Blake[3] gives $\frac{1}{20000}$ to $\frac{1}{30000}$ inch as the thickness of those of the recent Nautilus, and the Ammonite laminæ are about the same. These laminæ have been taken to constitute the primary structure of the shell,[4] and this idea is helped by the fact that the shell tends to split parallel to them, and thereby causes dissolution and re-crystallization to follow the same lines, by sucking the water into the cracks by capillary attraction; hence we see in the mineralized shell the laminæ reproduced. But under favourable conditions, as when the shell is preserved in clay, such as is beautifully seen in *Am.* (*Ludwigia*) *opalinus*, Rein., from Haresfield, this laminated structure becomes obliterated, while the real primary structure is preserved. This consists of innumerable prisms standing perpendicular to the surface, and united (probably, as we shall see later, by the interlocking of their component crystals) into a self-supporting tissue. These prisms also may be faithfully reproduced in other minerals, as in the Blackdown Ammonites, *Am.* (*Schloenbachia*) *varicosus*, Sow., and *Am.* (*Hoplites*) *denarius*, Sow., where the shell has a pink, faintly-iridescent hue, which may be converted into marked iridescence by soaking chips in Canada balsam, when they will show the prisms well, although they now consist of silica; and also in the Gault Ammonites, e.g. *Hoplites splendens*, Sow., where the pyritized prisms may be seen on looking at the surface with a $\frac{1}{4}$ inch objective by reflected light. In *Am.* (*Ludwigia*) *opalinus*, Rein., *Am.* (*Amaltheus*) *ibex*, Quenst., *Am.* (*Cosmoceras*) *Jason*, Rein., as they usually occur, the shell is white and opaque, though otherwise unaltered; when thin tangential sections of these are soaked in Canada balsam they become perfectly iridescent, and show unmistakably the prismatic- without the laminated-structure: shells which have the latter only are incapable of regaining their natural lustre. This deals the death-blow to the theory of iridescence caused by outcropping of the laminæ in fine lines, as illustrated by the celebrated Barton buttons; or by means of alternating films of different optical density, provided by the calcium carbonate and conchiolin; while it clearly indicates that

[1] F. von Römer, Jahresber. Schlesisch Gesells., Breslau, 1873.
[2] *Loc. cit.*
[3] British Fossil Cephalopoda.
[4] Carpenter, Brit. Assoc. Reports, 1847, p. 46; Sorby, Pres. Address, Geol. Soc., 1879, says the laminæ are pierced by fine needles of aragonite, p. 31.

the true cause is to be found in the ultimate structure of the prisms. In offering a new theory, I will suppose that calcium carbonate is deposited in the form of flat rhombohedra, since I have reason to believe that the shells of Ammonites and Nautili consist of calcite; but if the calcium carbonate crystallizes in the rhombic system, a similar form could be substituted without injuring the conclusion.

The shell substance as it is poured out from the mantle surface consists of a gelatinous mass, holding calcium carbonate in solution (mucoso-cretacée of Blainville[1]), and may be seen in that condition on the inside of a newly-opened oyster-shell. This homogeneous secretion hardens by the separation of the calcium carbonate in the crystalline state, while the conchiolin moulds itself around the growing crystal. Eventually, then, there is formed a thin membrane of conchiolin with innumerable flat rhombohedra lying imbedded in it; the animal matter on their broad faces forming the conchiolin laminæ, while that on the short faces forms the boundaries of the future prism. Now supposing the subsequent layers place their positive rhombohedra on the positive ones of the first, and the negative on the negative, we shall finally get two sets of columns leaning in opposite directions (Woodcut 2), such as



we find in the shells of Gasteropods.[2] If, however, the positive rhombohedra are placed on the negative ones of the layer before, and *vice versâ*, we shall get columns perpendicular to their base, but with a jagged outline (Woodcut 1). That the crystals of one layer have the power to influence those of the next is shown in the outer layer of the Nautilus, where the proximal granules are in optic continuity with the prisms below.

The latter of the two cases is that which may very well be imagined to obtain in the nacreous shells of the Cephalopoda; for it explains why the columns hold together so firmly, namely, by the interlocking of the projecting angles of the rhombohedra; and, also, light entering such a tissue would be reflected and broken up into its constituent colours by the myriad points, and would emerge coloured in all the tints of the rainbow, as we actually see to be the case. The conchiolin in the recent Nautilus is not very apparent round the individual crystals, owing to its being caught between the zigzag boundaries; but in the extreme edge of the section, where it

[1] Manuel de Conchyliologie, 1825.
[2] Rose, Abh. Akad., Berlin, 1858, also Carpenter, *loc. cit.*

is only one lamina thick, it becomes much more marked. Dotted about the tangential section there are specks of conchiolin which look as if they were tubules, but these are not seen in longitudinal section and may be explained as places where two adjacent crystals fail to interlock. In parallel polarized light, the tangential section of the prisms, which show as tiny ovals, are not isotropic, proving that they are not crystal prisms with basal planes; while in convergent polarized light a beautiful monaxial cross is given (as is the case also in the recent Nautilus), due probably to the aggregation of organic and inorganic particles.

In the longitudinal section of the extreme edge of the living-chamber of *Am.* (*Microceras*) *planicosta*, Sow., Fig. 1 (p. 253), the newly-formed prisms fan out slightly, producing a crinkling of the surface, which afterwards disappears by the straightening out of the prisms. This is due, undoubtedly, to growth by intussusception; not by means of actual canals as Kœnigsborn[1] and others have supposed, but rather by the shell-building material being passed on through the conchiolin, just as water in the soil is passed on from grain to grain, though no conduit is seen. Carpenter has also shown that slight intussusception goes on in the Lamellibranch shell, for he says that the boundaries of the prisms in *Mya arenaria*, L., become obliterated in old age.

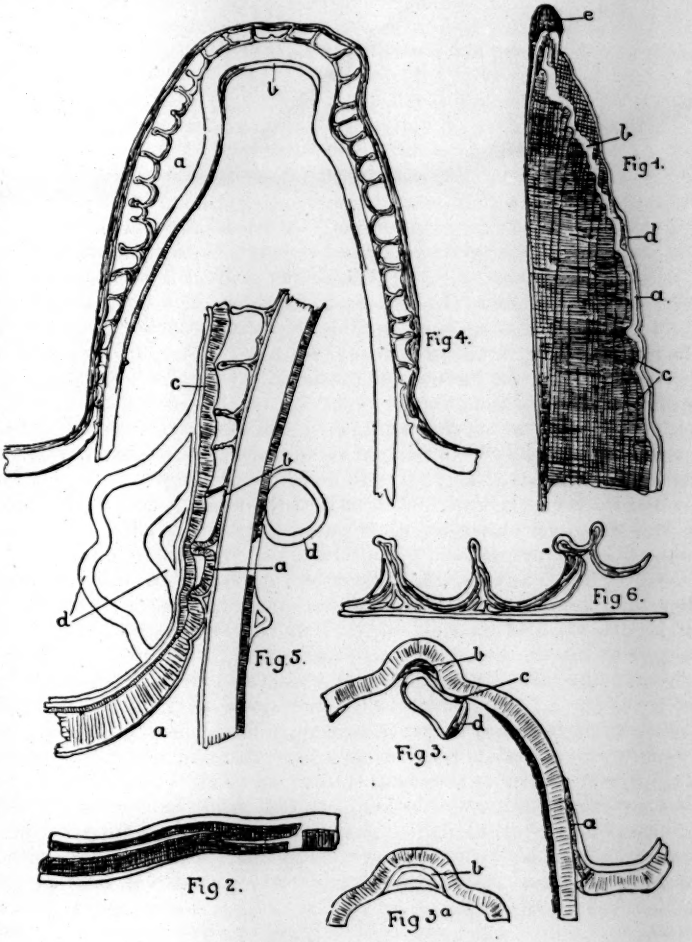
The outer layer, corresponding to the porcellanous one of the Nautilus, is usually taken to be represented by a clear crystalline deposit external to the prismatic zone, as is shown in *Am. planicosta* figured by Hyatt.[2] But my section, Fig. 1, of the same, from the same material, shows that this is nothing else than part of the inner layer, which has split before the rest, and so drawn in the re-crystallizing water, for the clear band is seen dipping inwards and separating the true prismatic layer at the edge. In another section, Fig. 2, showing the wall of the living-chamber, the evidence of the origin of this outer layer is still plainer. In most cases that I have examined the so-called outer layer in like manner seems to be the outer part of the prismatic layer re-crystallized; it is, however, probable that a porcellanous outer layer did exist, but, owing to its granules not being united into a self-supporting tissue, it was quickly dissociated on the death of the shell. Thus, in Fig. 1 the horny matter at the end seems to have terminated such a layer which has gone, while in a Lias nodule containing *Am.* (*Grammoceras*) *radians*, Schloth., there appears to be an actual granular layer (*a*), preserved between two adjacent whorls, Fig. 3. Again, in *Crioceras Calloviense*, Morris, there is a clear band of re-crystallized matter surrounding even the extreme edges of the spines; this is probably the representative of the outer granular layer, for if it were part of the inner, one would think that it would break through the bases of the spines.

[1] Untersuch. ü. crust. Panzer u. Mollusk. schaal., Berlin, 1877. Of course I do not mean here that growth from within can go on to the extent that Méry postulated, Hist. de l'Acad. rog. des Sci., Mém., 1710.

[2] *Loc. cit.*

The outer layer then, though it can be demonstrated in a few cases, is ordinarily absent in the preserved shells.

The septa of Ammonites are identical in structure with that of the nacreous layer, though the septa of the recent Nautilus presents many differences from the true nacre.



EXPLANATION OF FIGURES.

FIG. 1. Section of the extreme edge of the living-chamber of *Am.* (*Microceras*) *planicosta*, Sow. *a*, so-called outer layer passing between portions of the prismatic layer at *b*; *c*, prisms slightly bent from the straight line; *d*, layer separating the prismatic from the vanished outer layer; *e*, terminal rim of conchiolin.

FIG. 2. Section of the same showing the so-called outer layer running between portions of the prismatic layer.

Fig. 3. Section of *Am.* (*Grammoceras*) *radians*, Schloth., from Bridport, showing the fourth whorl with a granular layer, *a*, interposed between it and the next; *b*, deposit in the keel; *c*, siphuncle with the outer sheath, *d*, N.B. the shell-wall is not continued over the back of the smaller whorl.

Fig. 3*a*. A section of the fifth whorl showing the deposit (*b*) in the keel splitting to form the hollow keel.

Fig. 4. Section of the junction of the seventh and eighth whorls in *Am.* (*Amaltheus*) *margaritatus*, Schloth., showing the wrinkled layer. At *a* it has been pushed away from the inner shell; *b*, deposit in the keel, which does not split in this species.

Fig. 5. Portion of the same enlarged. *a*, *a*, nacreous layer of the larger whorl terminating abruptly at *b*; *c*, nacreous layer resting on the apices of the wrinkled layer, and which is not continuous with that of the sides of the shell; *d*, *d*, *d*, sections of the septa.

Fig. 6. Three wrinkles enlarged, from the same.

In forms with a hollow keel, constituting the group *Falcoidei* of v. Schwarz,[1] the space included in it is commonly considered to be bounded on the inner side by the prismatic layer, and on the outer by the porcellanous one.[2] I have not been able to examine the typical case of *Am.* (*Oxynoticeras*) *oxynotum*, Quenst., as all our English specimens are represented as casts; but what I have said about the doubtful nature of the so-called outer layer seems to throw suspicion on its ever so occurring. In *Am.* (*Grammoceras*) *radians*, Schloth, however, in about the third whorl, a thin layer of prismatic tissue arises in the keel, quite separate from the usual nacre; this grows in thickness as the shell increases in size, till about the fifth whorl it splits, and encloses a triangular cavity which eventually becomes the hollow keel in the adult. The cavity, then, is bounded by its own peculiar paries (*b*), and is really a separate tube closed at the end, and has all the nacreous layer external to it (see Fig. 3*a*). In *Am.* (*Amaltheus*) *margaritatus*, Schloth., a similar deposit occurs, but does not split. Whether the hollow keel is invariably formed in this way, I have not examined sufficient material to state.

An analogous phenomenon is the case of hollow tubercles whose cavity is cut off from that of the air-chambers; in casts, therefore, the prominences are not represented. Such is the case in *Am.* (*Liparoceras*) *Henleyi*, Sow., where the prismatic layer divides, and a thin bridge of nacre separates the two cavities.

That the chambers do contain gas, I think, is proved by those of the Nautilus containing a gas differing from ordinary air in its greater percentage of nitrogen[3]; and their use, I think, may be understood from the habits of their living relative, the octopus,[4] which are in all probability similar. This latter when it darts upon anything, such as a crab falling through the water, shoots backwards just above it, and the prey is caught in the swirl following in the animal's wake, and is easily surrounded by its arms. It would obviously be an advantage if the hinder portion,

[1] Inaug. Dissert. Tübingen, Salzburg, 1873.
[2] Hyatt, Arietidæ, p. 216; Haug, Neues Jahrb., 1885, pt. iii, p. 593.
[3] Vrolik, Ann. Mag. Nat. Hist., xii, 1843, p. 173.
[4] Steinmann, Berich. d. Naturforsch. Gesell., Freiburg, 1889, vol. iv.

or that which cleaves the water, were lifted up in readiness to spring, and this appears to have been one of the functions of the shell.

The peculiar layer interposed between two successive whorls in some Ammonites has been termed the "wrinkled layer" by Hyatt,[1] as a translation of the "Runzelschicht" of Sandberger[2] and Quenstedt,[3] or the "Conche ridée" of Barrande.[4] It is homologous with the "black layer" of the Nautilus, which sometimes presents a striated appearance.[5] It has been observed in *Clymenia* (*Oxyclymenia*) *striata*, Münst., and *Cl.* (*Oxyclymenia*) *pseudogonites*, Sandb.[6] In the Goniatites it is also, occasionally, seen,[7] as in *G.* (*Gephyroceras*) *intumescens*, Beyr., and *G.* (*Tornoceras*) *retrorsus*, v. Buch. In the early true Ammonites, also, it is very frequently well preserved, as in *Arcestes*, *Cladiscites*, *Ptychites*, *Gymnites*,[8] *Protensites*,[9] etc.; in the later forms it has not been so often recorded, but when it does occur it does so in a greater degree. In *Am.* (*Liparoceras*) *Henleyi*, Sow., it forms strong spiral ribs over the ventral wall. In *Am.* (*Amaltheus*) *margaritatus*, Schloth., it reaches its highest development, as was pointed out by Quenstedt,[10] and I have specimens from Dundry and Bridport showing it well. In the latter specimen the wrinkled layer arises about the fifth whorl, or at the age when the keel first becomes prominent, and in two more whorls attains the complexity figured in Figs. 4–6. In the more enlarged drawing (Fig. 5) the inner layer of the larger whorl is seen to end abruptly where it reaches the inner whorl, and takes part only in the first three wrinkles. At the fourth, the true wrinkled layer begins, consisting of a brown horny material pleated into steep parallel folds, which often split or bifurcate. In life it probably consisted of pure conchiolin; and as we often find a black material taking the place of conchiolin, as between the prisms of the shell of *Turbo pica*, the homology between the black layer of the Nautilus and the wrinkled layer is strengthened. Resting upon the apices of the folds is the dorsal inner layer, which is not continuous with the inner layer, such as is found on the free sides of the shell.

The only use that I can see for a layer so developed is that it served as a spring cushion whereby the shocks which the animal gave to its shell when shooting backward were deadened, the conchiolin being eminently adapted for the purpose. And this view is supported by the fact that in *Am. margaritatus* it first appears at the same time that the keel does, which was used to divide the water and allow the animal to dart more quickly.

[1] Bull. Mus. Comp. Zool., Cambridge, 1871, vol. iii, p. 91.
[2] Verstein. d. Rhein. Schichtsyst. in Nassau, 1850, p. 58.
[3] Petrefaktenkunde Deutschlands, pt. i, 1846.
[4] Syst. Silur., vol. ii, p. 23, 1867.
[5] Palæontographica, vol. iv, p. 184.
[6] Verhandl. d. Naturhist. Vereins. d. preuss. Rheinlande, 1853, vol. x.
[7] Keyserling, Reise in das Petschoraland, St. Petersburg, 1846, p. 274.
[8] Mojsisovics, Med. Trias Provinz, Abh. geol. Reichsanst., Wien, 1882.
[9] Hauer, Trias v. Bosnien, Denksch. Akad., Wien, 1892, vol. lix.
[10] *Loc. cit.* p. 93, fig. 14*d*.

Under the name "Epidermiden" there have been described markings on the inner surface of the living-chamber of the fossil-chambered Cephalopoda, which are probably homologous with the soft lattice markings on the inside of young Nautili.[1] Barrande (*loc. cit.*) has described them in detail for the fossil Nautili and Goniatites of the Silurian, under the name "stries creuses" (sometimes stries d'eraillure; German, Ritzstreifung[2]), and noticing that they are absent in forms with a contracted mouth, he argues that their function was to secure the animal in its shell. In these forms they consist of very fine close-set striations oblique to the direction of the ornaments of the shell. Similar structures are developed in Ceratites,[3] but especially in the Triassic Ammonites, *Ptychites*, *Klipsteinia*, etc. In later forms they have not been frequently observed, probably owing to the small attention paid to casts of the interior when specimens with the shell on can be obtained: however, I have noticed them in a large *Am.* (*Microceras*) *capricornis*, Schloth., from Chideock. The "stries creuses" were formed probably during the time that the hinder portion of the mantle was secreting the new septum; for, while that was going on there would be an absolute necessity for the animal to be kept firmly fixed in its new position, and to be able to withstand the pressure of water from without. The muscles of the mantle therefore became tightly stretched, thereby producing little ridges and hillocks around areas of non-compressibility, and a condition of things arose similar to the "goose-flesh" of the human integument, which is caused by contraction of the skin round the hair papillæ.

In *Am.* (*Deroceras*) *Dudressieri*, d'Orb.,[4] *Am.* (*Arietites*) *obtusus*, Sow., and *Am.* (*Arietites*) *stellaris*, Sow.,[5] there appears to be a third layer deposited on the exterior of the shell in senile forms, and presents an ornamentation which is unique among the vast series of forms.

The siphuncle in the Ammonites is often beautifully preserved as a horny tube frequently distorted from its normal circular form, Fig. 3. This is equivalent to the inner conchiolin sheath of the Nautilus' siphuncle, and in many cases (Fig. 3*d*) there is evidence of a sheath surrounding this inner one, but in no case that I have examined does this second one bear spicules as in *Nautilus pompilius*, L.[6]

[1] Sandberger, G., Schrift d. oberhess. Gesells. f. Natur u. Heilkunde, No. vii, p. 79, 1859.
[2] Sandberger, G., Jahrb. d. Vereins. f. Naturkunde, Wiesbaden, vii, p. 292, 1851.
[3] Eck, Zeits. deutsch. geol. Gesells., p. 276, 1879.
[4] Wright, Lias Ammonites, Pal. Soc., pl. xxv.
[5] Oppel, Die Juraformation, Jahresh. d. Vereins. f. Naturkunde, Stuttgart, vol. xii, 1855.
[6] Brooks, Proc. Boston Nat. Hist. Soc., vol. xxiii, p. 380.

V.—Note on Pseudo-Spherulites.

By Lieut.-General C. A. McMahon, V.P.G.S.,
and W. Maynard Hutchings, F.G.S.

THE January number of this Magazine contains an interesting paper on a soda-bearing rock from Dinas Head, Cornwall, read by Mr. Howard Fox, F.G.S., at the Oxford meeting of the British Association. Mr. J. J. Harris Teall, F.R.S., supplied notes on the microscopic structure of some of the specimens; and four chemical analyses by Mr. J. Hort Player and Mr. Arthur F. Hosking are given in the paper, from which it appears that the specimens analysed are composed of from 64 to 66 per cent. of silica; from 19 to 20 per cent. of alumina; 9·8 of soda; and small amounts (generally under 1 per cent.) of potash, titanic acid, ferric and ferrous oxides, magnesia and lime.

A sketch of a nodular spherulitic specimen is given at page 18, Geol. Mag. 1895.

In a subsequent paper[1] read by Mr. Fox before the Royal Cornwall Geological Society in 1894, other specimens from the same locality, the microscopical examination of which was undertaken by one of the authors of this paper, are described.

Some of the soda rocks from Dinas Head, which form the subject of this paper, contain a number of nodules closely resembling spherulites to which it seems desirable to invite the attention of petrologists. They are mostly in rounded forms, but owing to their interference with each other's growth, thin sections of them, under the microscope, sometimes present irregular hexagonal outlines. Superficially examined they greatly resemble true spherulites, and have been accepted as such by some good observers.

The main question which arises in connection with these spherulites is, whether they are of igneous origin, and denote a vitreous igneous rock, or whether they represent contact action exercised on a sedimentary rock. After a prolonged study of the specimens sent to him, General McMahon came to the conclusion that they are sedimentary rocks indurated and altered into a variety of porcellanite, or adinole, by contact metamorphism.

The structure of the base in which the pseudo-spherulites are imbedded might be described as micro-granular or crypto-crystalline; and it is not, taken alone, of sufficiently distinctive character to enable a petrologist to answer the above question offhand. One sees this structure in some altered sedimentary beds, and also in some igneous rocks. In such cases one has, before arriving at a verdict, to search for felspar prisms, or microlites, scattered about in the base, and these are rarely absent in rocks of igneous origin. In the rocks under discussion, if we exclude the pseudo-spherulites from consideration, not a single lath-shaped prism of felspar, or microlith, is to be found in the base. On the contrary, one of the slides contains evidence which points decidedly to a sedimentary

[1] Notes on the Cherts and Associated Rocks of Roundhole Point, Cataclews Point, and Dinas Head. Trans. R.C.G.S. 1894.

origin. Here and there a very fine-grained lamination is to be observed in the base. The micro-granules are arranged in perfectly parallel straight lines, very close together, and possess a rigidly parallel structure, like the lamination of a very fine-grained sedimentary rock, and unlike the foliation of an igneous rock. It seems altogether unlikely that a fine-grained laminated structure, like that seen in the slide referred to, in rigidly parallel lines, could have been produced here and there in isolated patches in a vitreous rock of igneous origin. Their presence, however, in a partially melted fine-grained sedimentary rock is easy of comprehension.

The pseudo-spherulites in the Dinas Head specimens present, on careful examination, some features different from the normal spherulites of glassy igneous rocks. The pseudo-spherulites do not exhibit a dark cross when revolved between crossed nicols. Indeed, the base of these sperulites, namely, the micro-granular, or crypto-crystalline material seen in the centres, and between the blades of the felspar prisms, which radiate from the margins of the spherulites towards their centres, does not possess a fibro-radial structure at all; and does not in any way differ in structure from the crypto- or micro-granular base outside the boundaries of the pseudo-spherulites.

In normal spherulites the radial fibres, or fibrous prisms, have straight extinction; whereas in the Dinas Head pseudo-spherulites the prisms which radiate from the outer edge towards the centre (which they never reach) are those of a triclinic felspar and have, in every case, oblique extinction.

The conclusion reached by General McMahon regarding the pseudo-spherulites of the Dinas Head soda rocks is, that they are the product of contact action by a basic trap on a sedimentary rock which either contained, in whole or in part, the chemical constituents of albite; or into which those constituents were introduced, in whole or in part, at the time the contact action took place.

As the presence of spherulites in a vitreous rock has been regarded by many petrologists as evidence of the igneous origin of the rock in which they occur; and as a metamorphic origin has not hitherto, so far as we are aware, been suggested for spherulites, this determination seemed worth noting.

The independent researches of Mr. Hutchings, in another locality, carried out at the same time, has supplied the needed confirmation. This confirmation is all the more important as no doubt can be entertained regarding the sedimentary origin of the rocks studied by Mr. Hutchings and described in the March number of this Magazine. They are shales forming part of beds of limestone, sandstone, and shales, in contact with the Whin Sill, and still retaining in their altered condition abundance of clastic quartz-grains and other witnesses to their original nature, even if this was not as positively assured as it is by the field evidence.

In these altered shales Mr. Hutchings describes at pages 124, 125 nodules which exhibit under the microscope much the same general character as those of the Cornish rocks, and which contain in some cases numerous well-developed spherulitic aggregates of fibres of

felspar and quartz, some of the best of which show tolerably good black crosses on rotation in polarized light, and are as well entitled, or even more so, to the name of pseudo-spherulites as are those in the soda rocks of Dinas Head.

The above observations, taken together, seem to establish conclusively that spherulitic structure is not, taken alone, evidence of the igneous origin of the rock exhibiting it; and, further, that spherulites are sometimes the product of contact-metamorphism.

VI.—On the Conversion of Olivine into Serpentine.

By Professor W. J. Sollas, D.Sc., F.R.S.

In the last volume of the Annals of British Geology (1893), just published, Professor Blake gives an abstract of a paper by me on "Variolite from Roundwood,"[1] and incidentally calls attention to the discordance between the formulæ given by General McMahon,[2] Dr. Roth,[3] and myself, to explain the conversion of olivine into serpentine. I hasten at once to correct a slight error which occurs in my equation, but which, fortunately, does not affect the principal result of the argument, as the correct formula was used in making calculations. Amended, my equation is as follows:—

$$2\,Si\,(O_2\,Mg)_2 + 2\,H_2O = Si_2O\,(O_2Mg)\,(OH)_2\,(O\,Mg\,OH)_2 + Mg\,O$$

Olivine — Serpentine (Tschermak)

or,

$$\text{Ditto} = Si_2\,(O_2Mg)_2\,(OH)_3\,(O\,Mg\,OH) + Mg\,O$$

Serpentine (Clarke and Schneider)

The fate of the molecule of Mg O on the right is not indicated here. General McMahon's equation is essentially similar to this, but less detailed. Roth's may be represented thus:—

$$5\,Si\,O_4\,Mg_2 + 4\,H_2O = 2\,Si_2O_9\,Mg_3\,H_4 + 4\,Mg\,O + Si\,O_2$$

Olivine — Serpentine

Since 4 Mg O + Si O_2 is equivalent to Si O_4 Mg_2 + 2 Mg O, it would appear that Roth puts one molecule of olivine into the left-hand side of the equation to take it out again on the right. The explanation of this is, that while four molecules of olivine suffice to supply the material of two molecules of serpentine, five molecules are needed to furnish the space occupied by this serpentine. The fifth molecule of olivine is carried away by water as well as one molecule of magnesia liberated in the process of serpentinization of the other four, and from this excess of material the minerals magnesite, hydrotalcite, and quartz, which are found associated with serpentine, are produced.

In my treatment of the process I simply pointed out that the hydration of olivine, by which it gives rise to serpentine, is accompanied by an increase in volume amounting to 30 per cent.,

[1] Sci. Proc. Roy. Dublin Soc. vol. viii, new series, p. 110.

[2] Proc. Geol. Assoc. vol. xi, p. 427.

[3] Abh. d. k. Akad. d. Wiss. Berlin, 1869, p. 329 (cited by Teall, British Petrography, 1888, p. 105), Chemische Geologie, Bd. i, p. 116.

the odd molecule of magnesia set free on the right-hand side of the equation being disregarded; and, since pseudomorphs of serpentine after olivine generally retain the precise form and dimensions of the crystals they replace, I conjectured that the surplus of 30 per cent. might be partly represented by the veins of chrysotile, which so frequently traverse serpentinous rocks.

Zirkel, in his great work,[1] discusses the subject, and points to an experiment of R. Müller,[2] who found that under the action of water containing carbonic acid powdered olivine lost a part of its silica and magnesia, and almost all its ferrous oxide, while the insoluble residue consisted of silica and bases in approximately the same proportion as in serpentine. The same distinguished author also suggests that the magnesia liberated from olivine may assist in the serpentinization of bronzite. I had already indicated that this might be possible (p. 110, *op. cit.*), but at the same time pointed out that the increase of volume in this case must be even greater than when olivine alone is concerned, as is shown in the following case:—

	Olivine.		Enstatite.		Water.		Serpentine.
Molecules	4	+	2	+	6	=	3
Volume	170	+	64·5	+	108	=	330

whence 234·5 volumes of olivine and enstatite give rise by hydration to 330 volumes of serpentine, an increase of 40 per cent. It will be observed that the volume of the water which enters into combination is neglected; if this be taken into account it will be found that in accordance with the general rule the volume of the final product is less than the sum of the volumes of its constituents.

A consideration of such changes as we have indicated is of interest from more than one point of view. The marked increase in the volume of the solid substances produced by hydration will lead us to look for the secondary minerals which must have been deposited in association with serpentine rock; while the large quantity of water absorbed in the reaction may well impress us with the important part played by the hydration of minerals in removing water from the liquid envelope and locking it up in the solid form within the earth's crust.

VII.—On the Age of the Trachytic Rocks of Antrim.

By Alex. McHenry, M.R.I.A.; Geological Survey of Ireland.

[Communicated by permission of the Director-General of the Geological Survey.]

SINCE the publication of the Geological Survey Maps and Memoirs of Antrim, some additional evidence has been obtained bearing on the age of the trachyte of that district. In the year 1888, when engaged in traversing a line of section running from Belfast in a northerly direction across county Antrim to the Giants' Causeway, I was fortunate enough to notice in a large chalk quarry at Templepatrick railway station evidence which

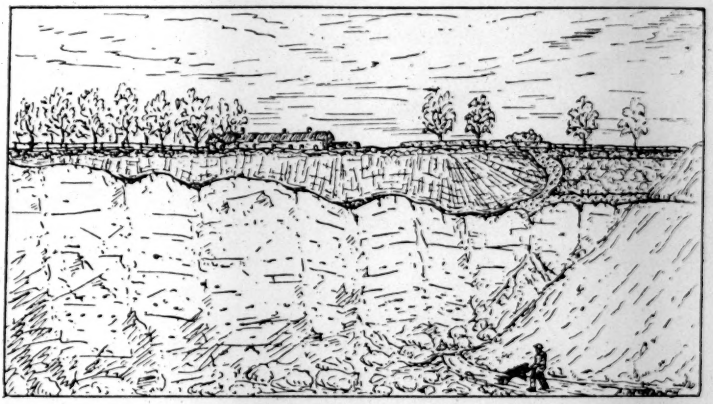
[1] Lehrbuch der Petrographie, 1894, p. 390.
[2] Min. Mitth. 1877, p. 36.

seemed to show that the trachyte was later than the Tertiary basalt sheets of the lower division; and, on further investigation into this interesting subject, additional evidence was procured that the trachytic eruption was older than the sheets of the upper series, and was, so to speak, of mid-basaltic age. Subsequently I accompanied the Director-General, Sir Archibald Geikie, on his visit of inspection to this locality, and he approved of my views. Professor Gilbert, of the United States Geological Survey, who was with us at the time, also agreed with the conclusions arrived at.

The accompanying sketches and sections will serve to illustrate the mode of occurrence of the trachyte and adjacent rocks. They were made at the time of my first visit to the quarry.

Fig. 1 shows the most important point in the evidence as to the relative ages of the trachyte and basalt. It will be seen that the trachyte during its eruption, in the form of a laccolite, swept the eroded chalk surface of its usual superincumbent flint gravel bed, which is composed of burnt chalk flints, chalk fragments, and

Fig. 1.



East end of Templepatrick Quarry, county Antrim, showing position of Chalk, gravel bed, Lower Basalt, and Trachyte. From sketch made in May, 1888.

red marly clay, and piled it up against the opposing and evidently pre-existing barrier of basalt, on its eastern side. The columnar structure in the trachyte is well marked, and has clearly converged, during the cooling process, from the outside towards the centre of the mass, while a beautiful and regular flow structure is apparent, running parallel to its outward margin, as shown in sketch.

Remnants of the flint-gravel bed are to be seen in a few pockets and hollows of the eroded chalk surface, which were evidently left behind in more or less sheltered places, while the igneous mass was advancing.

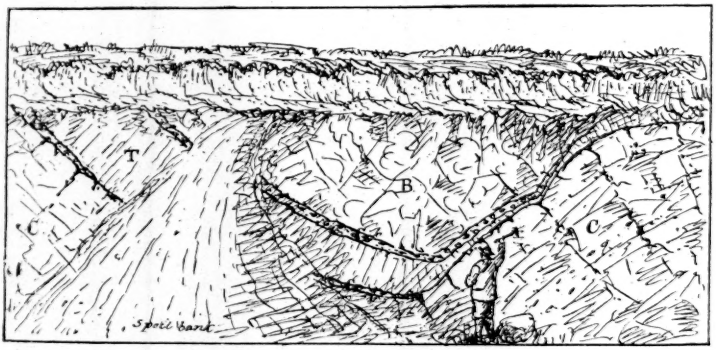
This gravel bed, where it is in contact with the trachyte, has been baked and indurated into a compact and solid flinty mass, while in every other instance in which I have seen it in its usual or

normal place between the chalk and basalt, it occurs in the form of a loose gravelly clay.

The trachyte in this locality is generally compact and fine-grained in texture, light-grey and white in colour, sometimes mottled pinkish; and on its weathered surface bears a close resemblance in colour to the underlying chalk, so much so, that a casual observer might at first sight suppose the chalk and trachyte to form portions of one rock-mass. The basalt is of the usual amygdaloidal character, and weathers spheroidally.

Fig. 2 shows the relative position of the rocks in the west end of the quarry, and it is interesting to note how the trachyte behaves in this instance. It has forced its way underneath the basalt along the zone of the flint-gravel bed, which it carries on its back, and at one place portions of the gravel bed rest both above and below it.

Fig. 2.



West end of Templepatrick Quarry, county Antrim.
C. Chalk. G. Flint-gravel bed. B. Lower Basalt. T. Trachyte.

At Ballypalady, $1\frac{1}{2}$ miles north-east of Templepatrick Quarry, evidence exists to show that the trachyte is older than the Upper Basaltic sheets, and at Libbert Bauxite Mine, near Glenarm, further proofs on this point are to be found in the trachyte-conglomerate and trachytic sands which occur between the Upper and Lower Basalts.

Fig. 3 is a section of the Ballypalady rocks which was, and is still, I believe, to be seen in the old open workings of the pisolitic iron-ore excavations. The bed of conglomerate contains rounded and subangular lumps and finer débris of the Templepatrick variety of trachyte, as well as fragments and detritus of the Lower Basalt, the whole being capped by Upper Basaltic sheets.

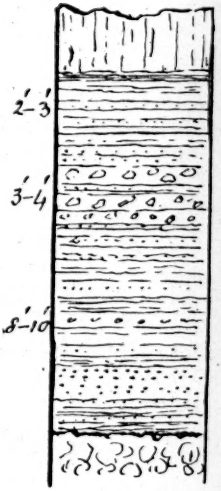
This is one of the localities from which beautiful plant impressions, leaves, fir-cones, etc., were obtained. These have been figured and described by the late Mr. W. H. Baily and Mr. J. Starkie Gardner.

Fig. 4 is a section of the Libbert Mine, Glenarm, from which a fine collection of plants, etc., was also obtained, when it was being worked for Bauxite some twenty years ago.

It may here be mentioned that those two plant localities are on the same geological horizon, namely, that of the widely extended pisolitic iron-ore zone of the county. The Ballintoy lignite, iron-ore, and Bauxite Mines are also on this horizon.

Fig. 3.

Ballypalady section, 1½ miles north-east of Templepatrick.



Upper Basalt (compact and often columnar).

Brown laminated shale and volcanic ash (?).

Laminated brown impure earthy lignite.

Brown and red variegated clays, marls, and sandy beds, with irregular layers of coarse conglomerate, composed of rounded and subangular fragments of trachyte and basalt.

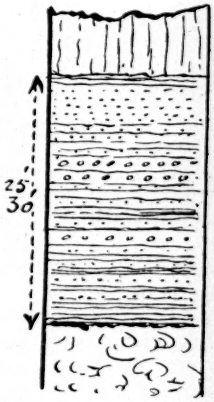
Brown, red, and yellowish laminated marl, mudstones, and bole, with occasional layers of fine conglomerate (trachytic and basaltic), pisolitic iron-ore band, and plant beds.

Lower Basalt (amygdaloidal).

The trachyte-pebbles and fragments in this place (Libbert) are of the type of rock that occurs in the great mass at Tardree Mountains, to the south-west. I have observed this trachyte gravel in two or

Fig. 4.

Libbert Mine section, Glenarm.



Upper Basalt (compact black).

Lignite.

Bauxite.

Whitish, grey, and variegated laminated trachytic clay, marl, sand beds, and pebbly trachytic conglomerate.

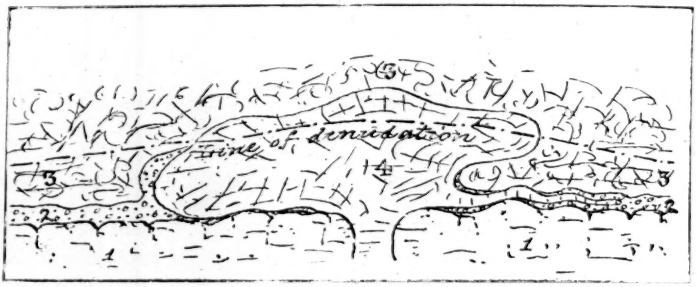
Whitish and grey fine-grained laminated trachytic beds, with plant remains.

Lower Basalt (amygdaloidal).

three other places between Glenarm and Tardree, and I have no doubt that it also exists in many other localities in county Antrim.

Figs. 5 and 6 are ideal sections, showing the probable conditions before and after the Upper Basaltic period.

Fig. 5.

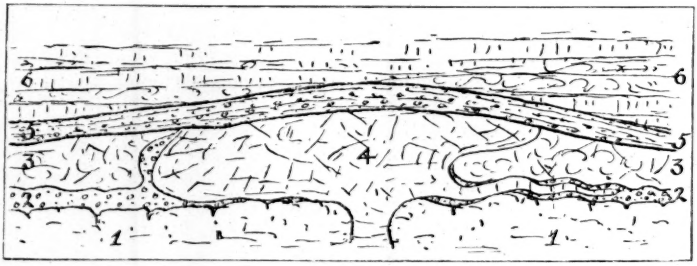


Ideal section showing probable mode of intrusion of the trachyte through Chalk and Lower Basalt.

1. Chalk with eroded surface. 2. Flint-gravel bed, composed of burnt chalk flints, chalk fragments, and red marly clay. 3. Lower Basalt. 4. Trachyte (laccolite).

Subsequent to my discoveries in county Antrim and, in the same year, when engaged in some work in the Mourne Mountain district, county Down, I was struck with certain similarities between the granite of this area and the acid rocks of county Antrim; namely,

Fig. 6.



Ideal section showing probable position of the (rocks) pisolitic iron-ore, trachyte gravel, and Upper Basalt, over the trachyte and Lower Basalt.

1. Chalk. 2. Gravel bed. 3. Lower Basalt. 4. Trachyte. 5. Horizon of denudation, along which were deposited the pisolitic iron-ore bed, trachyte conglomerate and sand, basaltic and ferruginous conglomerates, marls, and bole, containing plant and other remains. 6. Upper Basalt.

that the Mourne granite is often very trachytic in appearance, frequently resembling some of the varieties of the Tardree rock. It also cuts off basalt dykes, which are most probably of the Lower Basaltic series, and is itself, as well as these dykes, invaded and cut up by later basalts. Besides, there is a strong and most suggestive link between the rocks of the two areas (Antrim and Down) in the trachyte porphyry mass that occurs half-way between them, near Hillsborough, county Down. It is therefore highly probable that the Mourne granite is of Tertiary age.

VIII.—On a Recently Discovered Keuper Outlier near Kidderminster.[1]

By T. Crosbee Cantrill, B.Sc. Lond.

About two and a half miles east of Kidderminster, in North Worcestershire, is a wooded hill, marked and named Bissell Gorse on the original one-inch Ordnance Map [1831], Sheet 54, N.W. It is now on the six-inch Map [1882], Sheets Worcestershire VIII, S.E. and IX, S.W., named Bissell Wood. The hill lies just half-way between the villages of Stone and Churchill.

When examining the main Keuper-on-Bunter boundary, several years ago, in company with Mr. Walcot Gibson, now of H.M. Geological Survey, we were struck with the appearance of the hill as viewed from the main escarpment, and the idea occurred to us that possibly it would be found to be an outlier of Keuper, although mapped by the Survey as Bunter. Some time later I made a preliminary examination of the hill, and have more carefully examined and mapped it since.

The hill proves to be an outlier of Keuper Sandstone [f 5], resting on and surrounded on all sides by Upper Bunter Sandstone [f 3], the Keuper having been thrown down by a fault which runs along its south-east side, parallel with the main escarpment, half a mile to the south-east.

The relation of the outlier to the main mass of the Keuper is well seen from the one-inch Geological Map, Sheets 54 N.W. and 55 N.E., and from the accompanying Sketch Map and Section.

The lower boundary of the Keuper Sandstone arises on the eastern flanks of the Abberley Hills, where the Keuper rests directly on Silurian rocks. It then passes between Hartlebury and Stourport, having the Upper Bunter below, on the west, and Keuper on the east. The line then passes through the village of Stone, south-east of Kidderminster, then by the farm named Middle Dunclent, to Mount Segg—here running south-west and north-east—thence on to Broom, and so towards Stourbridge.

This boundary is marked by an almost constant escarpment, due to the greater weather-resisting properties of the Keuper beds and the extreme softness of the underlying Bunter, and this escarpment is specially bold on either side of Stone. Between Middle Dunclent Farm and Mount Segg, at about the position of the dip-arrow on the inch Map, the vertical distance between the edge of the scarp and the stream at its foot is about 130 ft.; and the scarp slope makes an angle of 20° with the horizontal, exceeding this towards the top.

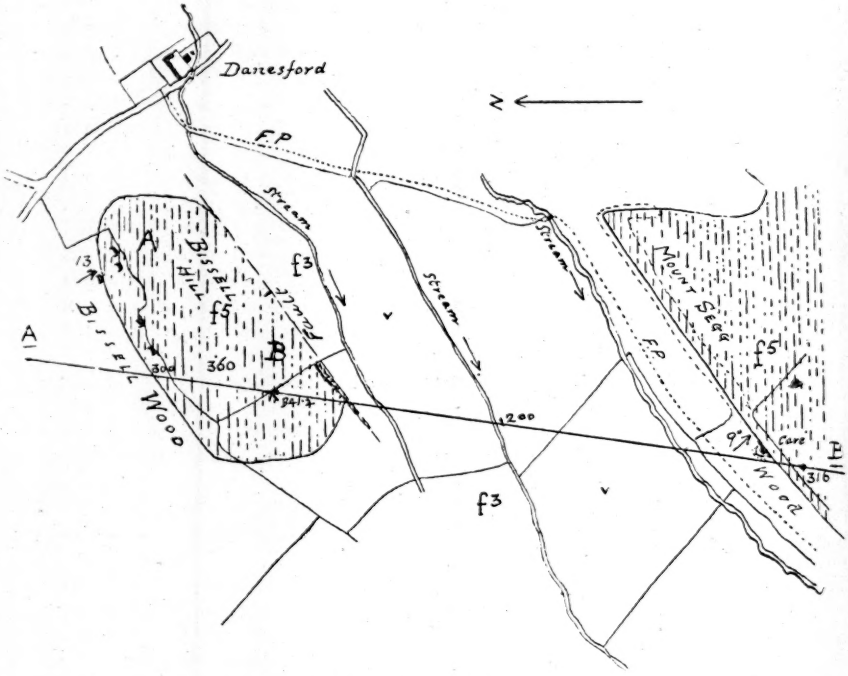
The shortest distance, measured at right angles to the strike, between the boundary line in the outlier scarp and that in the main scarp, is a little under half a mile.

The bottom of the broad valley excavated in the soft Upper Bunter between the outlier and the main escarpment is chiefly occupied by alluvial matter. Several streams flow through the

[1] Read before the Birmingham Natural History and Philosophical Society, Geological Section, Tuesday, 26th February, 1895.

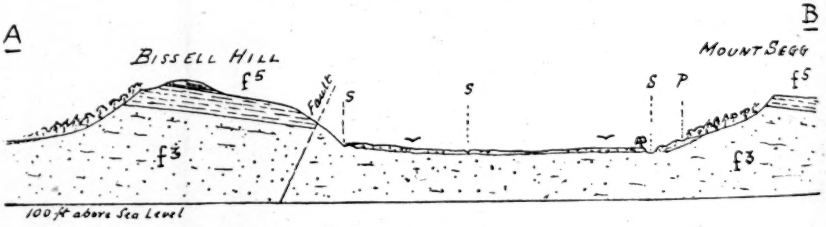
valley: that at the foot of the scarp is the natural course; the others are for irrigation purposes.

Viewed in plan the outlier presents the form of an irregular



Map of Bissell Hill and Mount Segg.

Scale: 6 inches = 1 mile. A—B = drift deposits.



Section through Bissell Hill and Mount Segg along line A—B on Map.

f 5, Keuper; f 3, Upper Bunter; ~ Alluvium; p, footpath; s s s, streams.

Scale: Horizontal, 6 inches = 1 mile. Vertical, 1 inch = 400 feet.

T.C.C. del. Dec. 1894.

ellipse, the major axis of which runs north-east and south-west, *i.e.* parallel to the main scarp. The greatest length is about 500

yards, and width 230 yards. It is marked along the north-west side by a steep wooded escarpment, formed by the ordinary weathering of the more durable Keuper basement beds overlying the soft Upper Bunter Sandstone. The boundary between the two formations runs along the scarp some yards below the summit, and sweeps round the north-east and south-west ends of the hill and runs into the fault which forms the south-east boundary along the whole length.

Viewed from the north-east or south-west the outlier is seen standing as a bold eminence in advance of the main escarpment. The general contour of the hill is represented with sufficient accuracy in the Section given above. The highest point is about 360 feet above ordnance datum. This is 44 feet higher than the crest of the main escarpment.

The main escarpment, at various points of its course, offers abundant rock-exposures. The Bunter, being usually too soft for building-stone, and too hard for sand, has seldom been worked. But the thin shelf of Keuper along the top of the scarp has been largely drawn upon for the foundations and lower courses of neighbouring farm buildings, and such-like purposes, and these old quarries, with their steep pick-scarred faces, offer excellent sections, especially as they have not been worked for many years. Several small openings occur on Mount Segg, but there is a much finer series along the scarp of the outlier itself, all long since disused. The principal of these are roughly indicated on the Sketch Map.

The basement beds of the Keuper [f5] in the district consist of a sandstone, coarse, usually thick-bedded, hard, but incoherent, and of a dull reddish-brown colour. There are in some beds small pebbles interspersed throughout the mass, usually of yellow and white vein quartz; but many consist of rolled fragments of a very fine dark-red clay or marl. In some sections, coarse, highly calcareous, hard bands—cornstones, locally known as catbrain—occur, consisting of a mass of small rolled fragments of red marl, and occasionally of quartz, embedded in sand, and the whole cemented together by an excess of calcium carbonate. One such band occurs at about 30 or 40 feet above the base, though apparently consisting not so much of a regular bed as of disconnected lenticular masses at about the same horizon. Some of the beds are fissile and highly micaceous, and occasionally marl bands occur.

The whole mass is exceedingly variable; it is practically impossible to fix any definite horizons, save, perhaps, that of the cornstones, and generally no two sections are exactly comparable—beds thinning out or entirely changing in lithological character in a distance of two or three yards.[1] Such is the general character of the basement beds of the Keuper [f5] in the district.

These beds in some sections rest on an apparently uneven surface of the Upper Bunter Sandstone, occasionally with a layer of rolled red marl fragments intervening. In other places the beds seem to pass into the underlying Bunter without any distinct plane of

[1] Consult Hull, "Permian and Trias Rocks of Midlands." 1869. Memoir of Geol. Survey.

separation, the change being signalized by a finer texture, softer nature, and brighter colour.

The Upper Bunter Sandstone [f 3] is a bright brick-red coloured sandstone, very fine-grained, soft, and altogether devoid of pebbles or fragments larger than the rest of the grains. It is normally thin-bedded, and fissile. If mica flakes occur, they are so small as to be almost invisible to the naked eye. The whole mass is practically homogeneous from top to bottom.

It should perhaps be stated that no fossils occur in any of these beds, whether Keuper or Bunter, in the district under consideration. Having given some account of the Keuper and Bunter beds of the main escarpment, we will now compare them with the rocks of Bissell Hill, taking the chief exposures in order, beginning at the north-east end of the outlier scarp.

1. Just outside the wood, on a rough, uncultivated patch of ground, at the bottom is seen typical Bunter *in situ*, and two feet higher coarse dull-red Keuper Sandstone, also *in situ*. By removing the turf in between, the Keuper is seen to grow finer, and then to abruptly pass into Bunter without any other change than that of colour. About three yards to the right, by digging, a few rolled fragments of red marl are found to occur at the junction.

2. Entering the wood, just in the angle, we find similar Keuper beds about 18 feet above the junction just described.

3. A few yards farther on, and close up to the hedge, is a conspicuous rock-face, and old débris cones, overgrown with herbage and sturdy trees, lie in front.

The section here is as follows, in descending order:—

Section at the East Quarry.	ft.	in.
1. Cornstone	1	0
2. Sandstone, hard, calcareous, greyish-red	0	6
3. Marl, friable, chocolate-coloured	3	0
4. Sandstone, thick-bedded, soft, coarse, and red, passing into 5	10	0
5. Sandstone, hard, highly calcareous	0	3
6. Shale, thinly laminated, soft, micaceous, and sandy, red-coloured	1	0
7. Grit, calcareous	1	0
	16	9

Notes on the above Section.

The beds 4 and 7 contain, irregularly distributed throughout the mass, small dark-coloured hard spheroids, about half an inch in diameter, and some smaller, formed by the grains of sand being cemented together by calcium carbonate and a manganese compound, probably the black oxide, MnO_2. These nodules being harder, stand out on the face of the rock, and are conspicuous by their darker hue. They effervesce with dilute H Cl, and are highly charged with manganese; a fragment treated by Hoppe-Seyler's test,[1] giving a bright pink colour due to permanganic acid. An apparently similar phenomenon was described by A. Norman Tate, F.C.S., to the Liverpool Geological Society in 1863, as occurring in

[1] See Fresenius, Qual. Chem. Analysis, edited by Groves, tenth edition, p. 122.

Trias Sandstone in that district. In several places the black sandstone was distributed much in the same manner as currants in an ordinary cake; a metaphor exactly descriptive of the case at Bissell Hill.[1]

4. A few yards farther on, and at a lower level, beyond an overgrown débris mound, is a small pit in front of a high face of rock, with abundant pick marks. The following section is afforded:—

Section at the Pit Quarry.	ft.	in.
1. Marl, friable, chocolate-coloured	1	0
2. Sandstone, soft, yellowish-red, with marly patches	1	0
3. Sandstone, fissile, micaceous, passing into 4	2	0
4. Sandstone, soft, dark, fine-grained	2	0
5. Marl parting	0	1
6. Sandstone, similar to 4	0	11
7. Marl, soft, micaceous, sandy, laminated, and fissile	0	4
8. Sandstone, soft, dull red, passing into 9	4	0
9. Sandstone, coarse, yellowish-red, with large quartz grains and a few large rolled marl fragments	1	0
10. Marl, friable, chocolate-coloured	0	3
11. Sandstone, dull red	0	10
12. Marl parting	0	1
13. Sandstone, similar to 11	1	1
	14	7

Probably the top beds in the Pit Quarry underlie the bottom beds in the East Quarry, with some few feet of intervening beds not exposed.

5. Beyond a débris mound, and at about the same level as the middle beds of the Pit Quarry, is a small crag of rock showing the following beds:—

	ft.	in.
1. Marl	0	6
2. Sandstone, fine, micaceous	1	0
3. Sandstone, soft, dull red	4	0
4. Sandstone, coarse, calcareous, with small marl pebbles	0	6
	6	0

These are probably beds 7, 8, and 9 of the Pit Quarry, though modified even in the short distance of about three yards.

6. Immediately below exposure 5 is the Bunter Quarry, the only one on the whole scarp. It shows nothing but the typical Bunter Sandstone, bright red, fine-grained, without mica or pebbles. It is thin-bedded, and dips into the hill at about 13°. The topmost beds in this quarry are six feet vertically below the lowest visible Keuper beds in the overlying exposure, so that the position of the boundary is here fixed to within about eight feet.

7. About the same level as the top of the Bunter Quarry, and some 30 yards farther on, is a small projecting crag of Bunter.

8. Higher up, and about 30 yards still further on, is a small crag of Keuper, probably concealed by vegetation during the summer.

9. About ten yards farther on, and close up to the hedge, is a small working in the Keuper, showing the following section:—

[1] See also Proc. Birm. Nat. Hist. and Mic. Soc. 1870, p. 55.

	ft.	in.
1. Sandstone, soft, fine-grained, micaceous, red, with greenish-grey spots	1	0
2. Sandstone, soft, coarse, very incoherent, dull red, passing down into 3	2	0
3. Sandstone, fine, dull red	12	0
4. Sandstone, calcareous, with large flakes of white mica	1	0
5. Sandstone, soft, fine-grained, dull red, passing down into 6	4	6
6. Sandstone, coarse, hard, calcareous, dull reddish-grey, with marl pebbles	0	6
[Below this the beds become very irregular by curved bedding.]		
7. Sandstone, coarse, soft, red, with marl pebbles	5	0
	26	0

These beds are probably of about the same horizon as those at the East Quarry.

10. Half a dozen yards further on is the West Quarry, the largest and last on the scarp. The bedding is very irregular, and the section is probably as follows :—

Section at the West Quarry.	ft.	in.
1. Sandstone, soft, red, at least	6	0
2. Marl band, irregular	0	2
3. Sandstone, laminated, fissile, micaceous	2	6
4. Sandstone, hard, coarse, dull red	4	0
5. Sandstone, hard, calcareous, dull reddish-grey	0	6
6. Marl band	0	2
7. Sandstone, like 4	3	0
	16	4

There is some faint resemblance here to the beds exposed in the quarry last described, half a dozen yards away.

11. Some considerable distance on, at about ten yards down the slope, are some shallow trenches in coarse dull-red sandstone, of the Keuper.

The above are the main exposures on the scarp slope. As the general dip seems to be about E.S E., probably the beds at the top of the East Quarry are the highest exposed along the scarp, and are about 35 ft. above the base: reckoning the lowest beds in the East Quarry to overlie the highest in the Pit Quarry, and the bottom beds in the latter to be about four feet above the Bunter.

A cornstone band crops out nearly at the top of the hill, and the summit, of dull-red sandstone, is about 60 ft. above the top of the Bunter: so that we have in the outlier a thickness of at least 60 ft. of Keuper beds.

At the south end of the hill, overlooking the valley, is a grassy bank, too steep for cultivation, along the bottom of which for some yards the fault rock projects in thick masses. Immediately below the fault rock the Bunter appears. The fault rock itself consists chiefly of slabs of very hard sandy rock, ringing under the blows of the hammer, highly calcareous, and dark-coloured with manganese oxide. It frequently contains small cavities. At certain points broken and slickensided fragments of Bunter occur. The slabs dip into the hill at an angle of 60°; the hade of the fault is therefore 30° and its direction is north-east and south-west, with the down-throw to the north-west.

A few feet higher up and at the south-west end of the bank, on

the downthrow side of the fault, a fine-grained sandstone occurs, only distinguished from typical Bunter by being somewhat paler. Probably this is, however, a fine-grained Keuper, as at the north-east end of the bank, a few yards away, and about a dozen feet higher up than the fault line, is a mass, *in situ*, of sandstone, coarse, soft, dull reddish-brown, micaceous, and containing rolled marl fragments — undoubted Keuper — so that the Keuper comes right down to the fault plane, or to within five or six feet of it.

We can roughly calculate the throw of the fault thus: At the cave in Mount Segg [see Sketch Map] the dip is 9° at right angles to the scarp. At the Bunter Quarry, on the Bissell Hill scarp, the dip is about 13° at right angles to the scarp. We may assume the dip to remain fairly constant for the distance between the two scarps. Taking its average value as 11°, which is equivalent to a rise of 1 in 5, and the rectangular distance between the respective boundary lines as 2200 feet, we have in 2200 feet a rise of 440 feet, *i.e.* the base of the Keuper at Bissell Hill, had there been no fault, would have been 440 feet higher than at Mount Segg. But we find that it is actually at about the same altitude, viz. 300 feet above sea-level. There must, therefore, have been a downthrow to the north-west of about 440 feet, and without this the Keuper would have been long since removed.

The fault is represented in the Sketch Map as a single line of fracture dying out in each direction. Whether this is really the case is open to question, as there is no evidence to be obtained. It may continue, perhaps, in a south-westerly direction to merge into a fault which passes near the village of Churchill,[1] each having a downthrow to the west.

Conclusion.—We have seen that the top beds of Bissell Hill agree perfectly with the Keuper Beds [f5] of the main escarpment, and that the lower beds of each agree in being undoubted Upper Bunter [f3]. The Keuper capping is isolated from the main mass and is therefore an outlier, and has been produced by the downthrow of a strike fault parallel to the two escarpments.

At A and B [on the Sketch Map] are scattered numerous rock fragments, chiefly derived from the Clent district to the north-east.

NOTICES OF MEMOIRS.

Note on a Paper on "Eozoönal Structure of the Ejected Blocks of Monte Somma."

In a letter to the Editor, Sir W. Dawson, of Montreal, has communicated his reasons for the belief that the appearances described lately by Dr. Johnston-Lavis and Dr. J. W. Gregory, in their paper on "Eozoönal Structure of the Ejected Blocks of Monte Somma,"[2] have no relation to *Eozoön Canadense*, either in mode of occurrence and mineral character or in microscopic structure. He

[1] See Geol. Survey Map, Sheet 54 N.W.

[2] Scientif. Trans. Roy. Dublin Society, series ii, vol. v, part vii, pp. 259-277, five plates; October, 1894.

refers especially to the typical specimens of Eozoön in which the laminæ remain as calcite, while the chambers are filled with serpentine, or more rarely with malacolite, and the canals and tubules with serpentine or dolomite.

1. As to mode of occurrence and mineral character, in the Vesuvian paper it is wrongly stated that the typical Eozoön is enclosed in a pyroxenic igneous rock. The best specimens have all been found in the thick "Grenville Limestone" of Sir William Logan, estimated by him at 750 feet in its average thickness, though with a few intercalated thin bands of gneiss and quartzite. In the vicinity of Côte St. Pierre in the Seigniory of Petite Nation, where some of the best specimens of Eozoön are found, the outcrop of this limestone has been traced continuously and mapped by the Geological Survey for twenty-five miles, and in the same district it occurs over an extent of more than one hundred miles on the reverse sides of synclinal and anticlinal folds, where it may be recognized by its character and associations as well as by its holding Eozoön. It is true that grains, nodules, and thin interrupted bands of a white variety of pyroxene (malacolite) occur sparingly in this limestone; but neither in their chemical composition nor in their mode of occurrence have we any proof or even probability of an igneous (intrusive) origin. This was the matured conclusion of the late Dr. Sterry Hunt; and Dr. F. D. Adams, at present our best authority on these rocks, is of the same opinion.

The Grenville Limestone has been much bent and folded, and with its accompanying beds has been subjected to regional metamorphism. In the Petite Nation localities, however, it has not, as far as known, been invaded by igneous dykes or masses.

Specimens of Eozoön included in this limestone vary from single individuals ranging from an inch to six inches in diameter to aggregated groups of a foot or more; and microscopic examination shows that, in some of the beds in which they occur, there are innumerable fragments showing the same structures scattered on the bed-planes, and associated with the minute globular chamberlets which I have named *Archæosphærinæ*. The specimens of Eozoön may be seen weathered out on the surfaces of the limestone exactly in the manner of Stromatoporæ on the surfaces of the calcareous rocks of the Cambrian, Ordovician, and Silurian.

In certain layers of the Grenville Limestone grains and concretions of serpentine and malacolite occur without Eozoön, and specimens of Eozoön with only so much of such minerals as may be contained in their chambers. There are also instances in which specimens of Eozoön occur attached to or partially imbedded in such nodules, just as Sponges and other organisms occur associated with flints in chalk, or as Stromatoporæ occur in connection with concretions of chert in Palæozoic limestones. The origin of the concretions themselves must have been contemporaneous with the formation of the limestone.

2. *Form and Structure.*—An inverted position of Eozoön seems to have been adopted by the authors of the paper and by Zittel.

Although the plates apparently show some of the forms described in the paper as lying parallel to igneous veins, and as their selvages, or as rounded masses like nodules and geodes, on closer inspection essential differences may be observed. The Vesuvian specimens consist of continuous laminæ of crystalline igneous matter, including interrupted or lenticular layers of calcite. Eozoön on the contrary, when well preserved, consists of a continuous skeleton of calcite made up of broad layers slightly pitted on their surfaces, and connected at intervals; while the siliceous material appears as a substance filling wide flattened mammillated chambers more or less limited, and presenting amœboid lobes at their extreme edges, and passing finally in the upper part into rounded chamberlets. This difference should commend itself to any palæontologist, but I am aware that it may be overlooked by cursory observers. Scores of specimens have been sent to me of banded rocks, supposed by their finders to resemble Eozoön, though, in arrangement of parts, the converse of it.

Perfect detached individuals of Eozoön are usually of inverted conical form, springing from a narrow base and widening upward in the manner of some sponges and corals. When close together they often become confluent, and when these confluent masses or layers appear to be hollow or doubled, I believe that this usually results from the folding of the containing bed; and the laminæ may be observed to be bent and crushed at the flexures.

In the specimens figured in the paper, the characteristic microscopic structures of Eozoön are entirely absent. There is no trace of the beautiful and complicated system of canals; and the fibrous structures compared with the minute tubulation are merely prismatic fibrous crystals, like the secondary veins of chrysotile which sometimes cross and deteriorate our specimens of Eozoön. With reference to these chrysotile veins, while their filling of minute and often transverse and branching cracks shows that they are merely aqueous deposits of later origin than the structures which they traverse, and while their appearance under high powers is very different from that of the tubuli of the calcite layers, they have no doubt been, when parallel to the layers, and in poor specimens, fertile causes of error. They are absent from the more perfect specimens. I may also explain that while the finely tubulated margin of the calcareous layers can be seen to terminate abruptly against the filling of the chambers, it passes gradually in the interior of the layer into the larger canals when these are present. Naturally also, the finely tubulated wall often fails to show its structure, just as anyone who has examined large series of sections of Nummulites may observe in these fossils; and the tubuli are often filled with dolomite or calcite very difficult to distinguish from the substance of the calcareous lamina.

The late Dr. Carpenter quite understood the distinction between the veins of asbestiform serpentine and the organic structures, and he hoped to have prepared an exhaustive memoir on the subject, including my material as well as his own. Had this intention been fulfilled many subsequent mistakes might have been avoided.

The writers of the paper do not seem to notice that in the St. Pierre specimens the fine canals and tubuli are often filled with transparent dolomite, difficult to perceive without very good preparations and properly managed light. In roughly prepared specimens, and without careful attention to illumination, these delicate structures are often quite invisible. I have sections properly prepared which show the finest and most complicated tubulation in a manner equal to anything I have seen in any fossil Foraminifera from more recent formations, while other slices cut from the same specimen, but possibly slightly heated or subjected to mechanical jars in polishing, show little except a curdled appearance of the serpentine and a multitude of cleavage-planes in the calcite. In like manner in preparing decalcified specimens, a little heat or an acid too strong or not quite pure may remove all the dolomitic casts of tubuli, and may erode those of serpentine. From causes of this kind I fear many who have pronounced very decided opinions on Eozoön have not actually seen perfect examples of its structure.

While, therefore, I must agree with the writers of the paper that their specimens from Somma belong to the category of those banded structures found in concretions and geodes, and at the lines of contact of igneous and aqueous rocks, with which those who have advocated the organic origin of Eozoön are not unfamiliar, and which they have all along been solicitous to distinguish from it, I must emphatically deny that they resemble, either in composition, mode of occurrence, or form and structure, the Laurentian Eozoön of Canada.

REVIEWS.

I.—Synopsis of the Air-breathing Animals of the Palæozoic [Rocks] in Canada, up to 1894. By Sir William Dawson, C.M.G., LL.D., F.R.S. Pages 71–88, from the Transact. Roy. Soc. Canada, Section IV, 1894.

LITTLE more than fifty years ago very few relics of any *air-breathing* animals were known to exist in strata of Palæozoic age. Since then Canada, especially the Eastern Province of the Dominion, has yielded numerous interesting examples of such animals, high in grade above the common kinds of fossil creatures of protozoan, cœlenterate, and molluscan families. Logan's discovery, in 1841, of fossil Batrachian footsteps in the Lower Coal-measures at Horton Bluff, in Nova Scotia, was the first indication of the existence of air-breathing vertebrates in the Carboniferous rocks (Proceed. Geol. Soc. London, vol. iii, 1842, p. 712). In 1844 Dr. King announced the discovery of foot-prints in the Carboniferous of Pennsylvania; and Von Decken the finding of skeletons of Batrachians in the coal-field of Saarbruck. The first discovery of the osseous remains of any Palæozoic land vertebrate in America was that of *Baphetes planiceps*, found by Sir W. Dawson in the Pictou coal-field in 1850 (Quart. Journ. Geol. Soc. vol. x, 1856,

p. 209, pl. ix. Described and figured in Dawson's "Air-breathers of the Coal-period," 1863, pp. 5–7, pl. i, figs. 1, 1*a*; and "Acadian Geology," 1868, pp. 328, 359).

In 1851 several relics of some small animals of the Batrachian kind (Amphibia), *Dendrerpeton Acadianum*, etc., were discovered by Dawson and Lyell in what had been the hollow stump of a tree in the coal-growth of Carboniferous times, at the South Joggins, Nova Scotia (Quart. Journ. Geol. Soc. vols. ix and x, "Acadian Geology," p. 362, etc., and "Air-breathers of the Coal-period," pp. 17–31, pl. iii). Other congeneric forms also were found under similar conditions in the same locality.

The first announcement of the discovery of fossil Insects in America was that by Hartt of the finding of four kinds of insect wings in the "Fern Ledges" of the Little-River Group of the Devonian (Erian) strata at St. John, New Brunswick, in 1862 ("Canadian Naturalist," new series, vol. iii, 1867, p. 205).

Insects had previously been found in the Carboniferous strata of Europe, and have since been traced back to the Silurian of France (*Palæoblattina*, Brong.).

A valuable digest of the Fossil Insects of North America, so far as then known, was communicated in 1868 by Mr. Scudder to the Geological Magazine, Vol. V, pp. 172–177, and pp. 216–222; and his well-known "Fossil Insects of North America, with Notes on some European species," was reviewed in the Geol. Mag. Dec. III, Vol. VIII, pp. 280–282, and Vol. IX, pp. 128–132.

The earliest known Carboniferous Millipede is the *Xylobius sigillariæ*, discovered by Sir W. Dawson in Nova Scotia in 1858; see Quart. Journ. Geol. Soc. vol. xvi, p. 271. Numerous other species of Millipedes have been found in the Devonian and Carboniferous of Europe and America.

Of the Arachnidans, both spiders and scorpions, or animals related to them, have been found in the Palæozoic strata of Europe and America. The scorpions are the most ancient group of the Arachnida, being represented in the Silurian rocks of Gotland and Scotland (*Palæophonus*) and North America (*Proscorpius*).

The first known (Carboniferous) Land-shell was discovered by Dr. Wyman and Sir C. Lyell in 1851 (Quart. Journ. Geol. Soc. vol. ix, 1852, p. 60, pl. iv), among the contents of one of the fossil tree-stumps, with *Dendrerpeton* from the South Joggins. Land-shells have been met with also in the Devonian plant-beds of New Brunswick (St. John), and in some coal-regions of America.

Thus in Canada have been discovered of Palæozoic air-breathers:—

1. Vertebrata, 26 species; all Amphibia.
2. Arthropoda, 33 species; Insects, Scorpions, Myriapods.
3. Mollusca, 5 species; Pulmonate Snails.

Of all the above the author gives a systematic account, with references to memoirs and books, and with the geological stages and the localities. Of group No. 1 there are nine genera of recognizable Microsaurian *Amphibia*; namely, *Hylonomus*, *Smilerpeton* (gen. nov.),

Hylerpeton, *Fritschia* (gen. nov.), *Amblyodon*, *Sparodus*, *Dendrerpeton*, *Baphetes*, *Platystegos* (gen. nov.). Also *Eosaurus*, of uncertain alliance; and two genera known from foot-prints only, *Sauropus* and *Hylopus*.

Of group No. 2 there are *Græophonus*, a pedipalp; *Mazonia* and *Palæophonus*, belonging to the Eoscorpioidæ; and *Eurypterella*, *Amphipeltis*, and another, of uncertain position. *Xylobius*, *Archiulus*, *Amynilyspes*, and *Euphoberia* are Myriapods; and *Palæocampa*, *Eileticus*, and *Ilyodes* are more or less related to them. The Insects comprise *Archimylacris*, *Mylacris*, *Petroblattina*, *Platephemera*, *Lithentomum*, *Homothetus*, *Xenoneura*, *Haplophlebium*, *Gerephemera*, *Dyscritus*, and *Archæoscolex*.

Of group No. 3 there are *Pupa* (*Dendropupa*), *Strophia* (*Strophella*), and *Zonites* (*Conulus*).

The author adds an interesting account of two fossiliferous tree-stumps lately observed by Mr. P. W. McNaughton at the Joggins coal-mine (pp. 84, 85); also a Note on the Devonian plant-beds at St. John, New Brunswick; and he gives some very useful suggestions for collectors.

II.—Granites and Greenstones. A series of Tables and Notes for Students of Petrology. By Frank Rutley, F.G.S.

MR. RUTLEY has done very good service by publishing this unpretentious little volume, a compendium of petrology, containing a very great amount of useful information in small bulk and convenient form. A glance at the interior of the book, with its long list of species and varieties of rocks, and compact table of minerals, will at once dispel any qualms which the associations of the title may not improbably stir, for it is at once evident that Mr. Rutley has no desire to recur to the period when everything was either a granite or a greenstone. He, however, thinks, and quite rightly, that the use of such terms by geologists in the field would often save errors which creep in when more exact determination is attempted without microscopic aid.

After indexing the symbols to be employed, the author at once gives us a table of rocks, which is clearly intended to be exhaustive, and to contain all the most important rock types. We notice a few omissions, such as some terms recently employed by Brögger, which seem to be of equal importance with others admitted to the table; nor is it quite clear why borolanite is placed with the dyke rocks rather than with the nepheline-syenites. The table depends on chemical composition, mineral constitution, structure, and to some extent on genetic relationship, and is probably as clear as in the present state of our knowledge it could be made.

Definitions of rock structures follow, but, unfortunately, they are not arranged even alphabetically, a defect to some extent atoned for by an index. Then the rocks themselves are defined, the unaltered rocks being placed by themselves and followed by the altered rocks; the felsites are considered in each division, while the porphyrites,

diabases, and picrite-porphyrites are placed only in the latter. Explanatory notes on the mineralogical tables succeed, and these contain a good many useful hints on the determination of some microscopical characters and the application of optical tests.

Finally come the determinative tables, arranged under such heads as the Felspars, Micas, Silicates and Oxides, Zeolites, Iron-ores, Alteration products, and the like, reference being made easy by a separate index of minerals.

The work is likely to be very useful to the beginner from the simplicity of its arrangement and the avoiding of all controversial matter, while even to the advanced student it will furnish a most valuable aid to memory, which will save the trouble of reference to larger works at the same time that it will make such reference more easy.

REPORTS AND PROCEEDINGS.

Geological Society of Glasgow: May 9, 1895.

The "Shelly Clays" and the Great Ice Age.—Mr. Dugald Bell, F.G.S., read a paper "On the High-level Shelly Deposits, and their bearing on the question of Submergence; with special reference to the recent edition of Dr. James Geikie's *Great Ice Age*." Dr. Geikie had intimated that he no longer believed in a "great submergence" of about 1400 feet during the Glacial period, which had been inferred from such high-level shelly "drifts" as those of Moel Tryfaen, in Wales. These, he admitted, were most probably transported to their present position by an ice-sheet. He still, however, believed in a submergence of from 500 to 600 feet, the evidence for which rests on one or two instances of high-level shelly clay in the west and north of Scotland. Indeed, it may be said to rest on only one instance; for the Aberdeenshire "beds," it was tolerably clear, could not be accepted as proofs of submergence; and another and, till lately, leading instance was in this edition "conspicuous by its absence." Chapelhall, near Airdrie, which had figured so largely in connection with this subject for forty years, and on which great stress was formerly laid by Dr. Geikie, is now entirely omitted, without a word of explanation! It seemed unusual to allow one's favourite facts thus to sink out of sight, without some brief *In Memoriam* being inserted where they once figured so largely. But Chapelhall being thus summarily discarded, Clava, near Inverness, which had become known since the last edition, might be said to be the single instance on which Dr. Geikie had to rest his proof of a submergence of about 500 feet. It was, so to speak, the "a'e button," which had to bear a great "responsibility." Accordingly, in this edition, much is made of Clava. A minority of the investigating committee were inclined to think that the shelly deposit there may have been transported by ice to an elevation of 500 feet, just as that of Moel Tryfaen had been to an elevation of 1400 feet. But Dr. Geikie will have none of this. Moel Tryfaen he admits, but Clava, he thinks, would be a "freak" of the ice, and

a "remarkable performance." The argument that if there had been a submergence to the extent of 500 feet, we should find traces of it in innumerable localities up to that level—though formerly it appeared to himself unanswerable (second edition, p. 390)—Dr. Geikie now dismisses by saying "it does not necessarily follow." The submergence, he supposes, may have been sudden and of short duration; or marine life may have been scanty; or all traces of it may have been removed by a subsequent glaciation. With all deference, these appear to be greater "freaks" and more "remarkable performances" than any imagined on the other side; and they include not only the ice but also the sea and the solid land. The last supposition, which is the most plausible, has been dealt with elsewhere,[1] and can be refuted in Dr. Geikie's own words (pp. 108, 109, 112, etc.). With regard to Clava, it can be maintained that there is nothing in the deposit that necessitates having recourse to a submergence; but much, in addition to the absence of traces of it at a similar level elsewhere, that is inconsistent with it. Dr. Geikie spoke of the shelly clay having been "dragged forward underneath an ice-sheet" for a distance of ten or twelve miles; but he can hardly insist on this particular mode of transport, seeing he informs us that "stones or boulders, once imbedded in the ice, might travel for hundreds of miles without suffering abrasion" (p. 204). Even the apparent extent of the deposit—which appeared to be Dr. Geikie's principal, if not sole, difficulty—if granted as proved, did not seem to be an insuperable objection to the ice-theory. Numerous instances were known in which large masses of clay and sand, and thin slabs of chalk, etc., had been transported uninjured by the ice. But whatever weight attached to this objection depended entirely upon the assumption that the deposit had all been transported by the ice at once, or *en masse*; which, to use Dr. Geikie's words, "does not necessarily follow." It may have been transported very gradually, and accumulated in an extra-glacial lake, formed at this part by the ice-sheet passing across a bend in that range of hills along whose base its course lay. An examination of the locality showed the extreme probability of this suggestion, which was submitted as at least preferable to sudden and transient submergences of 500 feet—seas with scarcely any marine life—and glaciers that cleared away all traces of a former sea-bed, over only part of which they could have passed. It not merely removed the objection referred to, but also accounted in some degree for several features of the deposit which, on the theory of a submergence, seemed inexplicable—such as the absence of all traces of currents in the clay, yet the worn and rounded stones imbedded in the heart of it; the sharp line of distinction between it and the other parts of the section; its wide difference from these in composition, etc. Reference was then made to the frequent elevations and depressions which Dr. Geikie still favoured during the Glacial period; their want of harmony with what had been observed in other parts of the northern hemisphere; their improbability in themselves, and especially in the repeated

[1] Trans. Geol. Soc. Glas. vol. ix, pp. 109, 110.

conjunction, according to his scheme, of submergence with severe conditions of climate (pp. 312–3, 324–5, etc.). So far as could be seen, submergence, by diminishing the extent of high land and more freely admitting the ocean-currents, must have been favourable to milder climatal conditions, as Lord Kelvin, in his paper on "Geological Climate," had shown. Mr. Bell concluded by expressing his high respect for Dr. Geikie, though obliged on these points to differ from him. A discussion followed.

GEOLOGICAL SOCIETY OF LONDON.

I.—April 3rd, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "Physical Features and Geology of Mauritius." By Major H. de Haga Haig, R.E., F.G.S.

The greater part of the surface of Mauritius is composed of a volcanic breccia; here and there lava-streams occur in the sections exposed in ravines, and sometimes on the surface. The commonest lavas are dolerites.

In at least two places sedimentary rocks occur at considerable elevations; in the Black River Mountains at a height of about 1200 feet a clay-slate is found, and near Midlands in the Grand Port group of mountains a chloritic schist is found at an elevation of about 1700 feet, forming the hill of La Selle; the schist is much contorted, but seems to have a general dip to the south or south-east.

Evidence of recent elevation of the island is furnished by masses of coral-reef and beach coral-rock standing at heights of 40 feet above sea-level in the south, 12 feet in the north, and 7 feet on the islands situated on the bank extending to the north-east.

The author gives full details of the physical geography of the island, including the nature and composition of the mountain-ranges, the depth of the ravines, the occurrence of caverns in the lavas, and the character of the coral-reef surrounding the island. Information is furnished concerning the neighbouring islands, and reference made to the possible former existence of an extensive tract of land at no great distance from Mauritius.

2. "On a Comparison of the Permian Fresh-water Lamellibranchiata from Russia with those from the Karoo Formation of Africa." By Dr. Wladimir Amalitsky, Professor of Geology in Warsaw University. (Communicated by Dr. H. Woodward, F.R.S., Pres. Geol. Soc.)

The fresh-water shells from the Russian Permian deposits belonging to the genus *Palæomutela* are also known from the Karoo Beds of South and Central Africa, as pointed out by the author in 1892. He has recently had the opportunity of studying the actual specimens from the Karoo Beds, and finds in them species of the groups *Palæomutela Inostranzewi*, *P. Keyserlingi*, *P. Verneuilii*, and *P. Murchisoni*; also of a new genus, the forms of which he had previously referred to *Naiadites*, Dawson. All these groups are found also in Russia, and he gives a list of species found

in the upper horizons (A, B, and C) of the Permian beds of Russia, and in the Karoo Beds. These upper beds of Russia have been determined by the author as the fresh-water equivalents of the Zechstein; consequently the Beaufort Beds of the Karoo series, if considered as the homotaxial equivalent of the European strata referred to above, should be regarded as Upper Permian. The Upper Permian group of fresh-water lamellibranchiata of Russia, which bears traces of genetic relationship with the Carboniferous Anthracosidæ, and which was already well represented in Permo-Carboniferous and Lower Permian times, is, according to the author, much older than the African fauna of the Beaufort Beds. These may be concluded to have migrated from Russia, the Gondwána Beds of India having probably been the connecting-link between all these deposits.

The author gives a description of the fossils of the Karoo series which he has examined, including a diagnosis of the new genus, in which he places the fossils already alluded to as having been previously referred to the genus *Naiadites*.

3. "Ice-plough Furrows of a Glacial Period." By W. S. Gresley, Esq., F.G.S.

The furrows described in the paper occur in the Coal-measures of north-west Leicestershire. The author considers that they were formed about the time of the Glacial period by floating ice.

II.—April 24th, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Shingle Beds of Eastern East Anglia." By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

The author has carefully examined the country around Southwold, where the beds known as Westleton Beds (which might well have been associated with the name of Southwold) are developed. He alludes briefly to the recent shingle, whose pebbles are derived from the ancient shingles of the cliffs; the formation of this shingle, he maintains, may belong to a time not far removed from our own day.

Turning to the Westleton Beds, he notices that they are essentially "drifts," the component pebbles not having been shaped on the spot, but brought as pebbles from elsewhere; and he gives reasons for supposing that they were derived from pebbly beds in the Lower London Tertiary group and in the Red Crag. He also maintains that the shells of the Westleton Beds and Bure Valley Beds are derived from Crag deposits. Reasons are given in the paper for supposing that the pebbles of the Westleton shingle of East Anglia came from the west, and that this moved eastward from the plateau of Suffolk towards the sea. It is considered that these beds can only be explained by a tumultuous diluvial movement.

2. "Supplementary Notes on the Systematic Position of the Trilobites." By H. M. Bernard, Esq., M.A., F.L.S., F.Z.S. (Communicated by the President.)

Since the publication of a paper by the author in the Quarterly

Journal of the Geological Society for 1894, two important papers by Dr. Beecher have appeared, giving details as to the structure and appendages of *Triarthrus*.

In the present paper the author discusses in detail the more recent discoveries in the light of the affinity between *Apus* and the trilobites, and endeavours to show how the results obtained by Dr. Beecher bear on the larger question as to the suggested origin of both of these animals from a chætopod annelid modified in adaptation to a new manner of feeding.

3. "An Experiment to illustrate the Mode of Flow of a Viscous Fluid." By Prof. W. J. Sollas, D.Sc., LL.D., F.R.S., F.G.S.

The author, recognizing that it is by a knowledge of the laws of viscous flow that we must seek to extend our information concerning the movements of flowing ice, conducted an experiment, the details of which are described in the paper, with a model of a glacier composed of the modification of pitch usually known as "cobbler's wax." In the model the pitch moved under its own weight over the horizontal floor of a trough, which was crossed by a barrier to represent an opposing mountain or the rising end of a lake. The results of the experiment showed that the movement of the pitch-glacier was not confined to that portion of it which rose above the barrier, but extended throughout its mass, and that an upward as well as forward movement took place as the barrier was approached. Thus the transport of stones by glaciers from lower to higher levels was by no means an incredible phenomenon, but a necessary concomitant of such simple conditions as those assumed in the experiment.

III.—May 8th, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "The Stirling Dolerite." By Horace W. Monckton, Esq., F.L.S., F.G.S.

The rock described in the paper forms a mass about eight miles in length, with an average width of about a mile; it is intruded into the lower part of the Carboniferous Limestone series. There is little doubt that the Abbey Craig rock, north of the Forth, is connected with the Stirling rock; and there is reason to think that the igneous rocks of Cowden Hill and of the hills around Kilsyth are outlying portions of the Stirling rock, being connected with it underground.

All these patches, as well as the main mass, are for the most part composed of a more or less coarse-grained dolerite, the marginal part always becoming finer-grained, whilst the actual edge has apparently been a tachylyte now devitrified.

The author gives the results of his macroscopic and microscopic examination of the rocks from various parts of the mass. He describes rocks from the centre, and also towards the bottom and top of the main mass, including actual contact-specimens from the bottom at Sauchie Craig and from the top at Sauchieburn as well as contact-specimens from minor sheets; and he infers

that the sequence is somewhat as follows (beginning from the centre:—

(i) Coarse-grained ophitic dolerite, forming the greater part of the mass.
(ii) Fine-grained ophitic dolerite, say 10 to 20 feet from the margin.
(iii) Basalt with *very little* augite, and with rods of iron-oxide.
(iv) Basalt with porphyritic plagioclase-crystals in a groundmass of microliths of plagioclase and hairs and rods of iron-oxide, having *no* augite. This occurs as near as $\frac{1}{2}$ an inch to the junction, and as far as 5 inches away from it.
(v) Basalt with porphyritic plagioclase in a gray groundmass, say $\frac{1}{10}$ to 1 inch from the margin.
(vi) Basalt with porphyritic plagioclase in a groundmass which is sometimes spherulitic; about $\frac{1}{10}$ inch thick on the average.

2. "Notes on some Railway Cuttings near Keswick." By J. Postlethwaite, Esq., F.G.S.

Several cuttings have recently been made on the Cockermouth, Keswick, and Penrith Railway, chiefly through drift, though some occur in the Skiddaw Slates, and in one case a diabase dyke (much decomposed) was met with.

The author describes the drift as blue clay beneath, and brown clay above, and considers that these two clays were produced during two separate periods of glaciation, with no long interval between. In some places near Keswick water-borne gravel may be seen surmounted by blue clay; this gravel is considered by the author to be of fluviatile origin.

The author has searched both blue and brown clays diligently for shells, but hitherto without success.

3. "The Shelly Clays and Gravels of Aberdeenshire considered in Relation to the question of Submergence." By Dugald Bell, Esq., F.G.S.

The drifts of this region have been described by Mr. Jamieson, and also in the publications of the Geological Survey. The two authorities agree that the Lower (gray) Boulder-clay of the district was produced by a local glaciation. The Geological Surveyors, however, maintain that the intervening sands and gravels with marine shells were produced during a submergence of 500 feet or upwards, whilst the Upper (red) Boulder-clay was formed by an ice-sheet from the south. Mr. Jamieson, on the other hand, assigns a purely glacial origin to the Middle Sands and Gravels, and considers that the Red Clay (which contains a few fragments of marine shells) indicates a submergence.

The author discusses these views, and maintains that submergence is not proved in the case of either Middle Gravels or Red Clay, but that the former are, as Mr. Jamieson maintained, truly glacial, whilst he advocates the existence of extra-morainic lakes to explain the latter.

CORRESPONDENCE.

SCOTTISH INTER-GLACIAL BEDS.

Sir,—Kindly allow me a few lines in reply to Mr. Clement Reid's statements in the last number of this Magazine. Mr. Reid doubts the inter-Glacial age of certain deposits which have been described as occurring between Lower and Upper Boulder-clays at Cowden Glen, in Lanarkshire, and at Hailes Quarry and Redhall Quarry, near Edinburgh, brief reference to which is made at p. 99 of my "Great Ice Age," third edition. I shall take the cases seriatim.

1. *Cowden Glen.*—Mr. Reid has not visited this locality, and the section has been obliterated for some years. He objects to the fossiliferous beds being classed as inter-Glacial, for two reasons: (1) because in some material sent to him for examination he detected two seeds of the garden poppy, and (2) because the whole assemblage of plants and the state of preservation of the animal remains suggest to him an extremely recent date for the deposits. Now, had Mr. Reid perused a paper read by Mr. Bennie to the Geological Society of Glasgow in 1889, he would probably have expressed himself less decidedly. The material examined by Mr. Reid was washed from the peaty silt by Mr. Bennie in 1868 and 1869, and had lain aside for twenty years before it was submitted to Mr. Reid's inspection. Among this material, some obtained from another observer was included by Mr. Bennie. It is not unlikely, therefore, as Mr. Bennie admits, that the two poppy seeds might have found their way accidentally into the collection during the long time it lay in his possession. It is even not impossible that they might have been accidentally dropped into the packet by Mr. Reid himself. The latter is quite sure they are poppy-seeds, but, under the circumstances, it might have been as well had he got some botanist to confirm the determination. So much then for Mr. Reid's first objection. Now for his second. I am afraid that his inference from the fresh appearance of the organic remains does not go for much. Mr. Bennie, whose greater experience gives weight to his opinion, says that the remains are no fresher than might have been expected. Mr. Reid, having apparently made up his mind that Scottish inter-Glacial beds should not contain a temperate flora, seems to think that this preconceived notion of his should be accepted as an argument against the inter-Glacial age of the Cowden Glen beds, in which the relics of such a flora were certainly found. He must excuse me if I decline to accept his dictum as to what the organic contents of an inter-Glacial bed should be. Upon the whole, I think I am justified in putting more trust in the evidence of my own eyes, and in the corroborative testimony of my former colleagues on the Geological Survey and others, than in his not very remarkable discovery of two supposed poppy-seeds in a collection of washed materials which had been lying past for twenty years before it came into his hands.

2. *Hailes Quarry.*—Here Mr. Reid has succeeded in finding a

mare's nest. He says that he saw no Boulder-clay resting upon the Arctic-plant beds. I should have been surprised if he had. If, before venturing on his criticism, he had troubled to read my reference to these beds ("Great Ice Age," p. 303) he would have found that I described them, along with the Corstorphine Arctic-plant beds, as occupying hollows in the surface of the Upper Boulder-clay. They are clearly younger than any Boulder-clay in the Scottish Lowlands. The inter-Glacial beds, formerly so well exposed underneath the Upper Boulder-clay in the quarry at Hailes, and described by me in "Prehistoric Europe," p. 256, are no longer visible. If Mr. Reid had asked Mr. Bennie he would have escaped falling into error, and would have learned that the inter-Glacial peat described by me and the Arctic-plant beds discovered by Mr. Bennie occurred on two separate and distinct horizons. I may add that no material obtained from the Hailes inter-Glacial beds has ever passed into Mr. Reid's hands.

3. *Redhall Quarry.*—This section was described and figured by Mr. John Henderson twenty years ago (Trans. Edin. Geol. Soc., vol. ii, p. 391). Mr. Henderson is a very careful and experienced observer, and knows the geology of the district well, and I have been content to rely upon his evidence. But I may mention that many other members of the Edinburgh Geological Society visited the quarry when it was first opened, and no one ever doubted that the glacial deposits occupied their original position. I did not myself see the section until long afterwards, by which time it had become more or less obscured, but nothing observed by me tended to throw any doubt upon the accuracy of Mr. Henderson's description. The situation of the quarry was familiar to me before the ground had been broken into for quarrying purposes. It was a slight depression lying between gentle slopes, from which no slips or slides of Boulder-clay could possibly have taken place. Mr. Henderson confirms my recollection of the facts, and informs me that at the time the quarry was opened undisturbed Boulder-clay extended continuously over the whole area. It was only when this Boulder-clay had been dug through that the inter-Glacial peat was disclosed. If it were the case that the plants recorded by Mr. Reid as having come from this place and Cowden Glen could not possibly have lived in Scotland during inter-Glacial times, I should be compelled to come to one of two conclusions—either (*a*) that Mr. Reid's unconfirmed botanical determinations are not necessarily infallible, or (*b*) that he has inadvertently mixed his samples or confused his localities, or both.

I have not noticed all Mr. Reid's statements and expressions of opinion which lay themselves open to animadversion, but have probably said enough to show that his attempt to discredit observations made by myself and others has not been quite successful.

EDINBURGH, 3*rd May*, 1895. JAMES GEIKIE.

OBITUARY.

JAMES DWIGHT DANA.

BORN FEBRUARY 12TH, 1813. DIED APRIL 14TH, 1895.

THE announcement of the death of this eminent geologist and zoologist will be received with deep regret by the readers of the GEOLOGICAL MAGAZINE. Dana was born at Utica, New York, and entered Yale College, graduating in 1833. On leaving Yale, he entered the service of the United States Navy as teacher of mathematics to midshipmen. In this capacity he visited on board the "Delaware" and the "United States" a number of the seaports of France, Italy, Greece, and Turkey, the cruise lasting fifteen months.

In 1836 he became assistant to Prof. Benjamin Silliman, the mineralogist. In 1837 he published his "System of Mineralogy," a work which obtained a worldwide reputation, and which ran through numerous editions, of which the last was issued in 1892. Dana was next appointed Geologist to the Wilkes Exploring Expedition, which sailed in 1838 and returned in 1842. "The expedition consisted of five ships, the route pursued being briefly as follows:—First to Madeira, then to Rio Janeiro, down the coast and through the Straits of Magellan, after passing which, while on board the 'Relief,' he nearly suffered shipwreck off Noir Island, the ship remaining for three days and nights in extreme peril: in the same storm one of the smaller accompanying vessels was lost. Then to Chili, Peru, and across to the Paumotus, to Tahiti, and the Navigator Islands; then to New South Wales, where the Naturalists remained while Commodore Wilkes went into the Antarctic; then to New Zealand, the Fiji Islands, where two of the officers were murdered by the natives; to the Sandwich Islands, the Kingsmill group, the Caroline Islands, and thence north to the coast of Oregon. Here, near the mouth of the Columbia river, the 'Peacock,' the ship to which Dana had been assigned, was wrecked, entailing the loss of all his personal effects, as well as many of his collections. He was, then, one of the party that crossed the mountains near Mount Shasta, and made their way down the Sacramento River to San Francisco. In his report of the expedition he states that the geological features indicated the probable presence of gold. This was six years before the discovery of gold in California, and rich mines have since been discovered in the region over which the party went. At San Francisco they were taken on board the 'Vincennes,' and the homeward voyage was made by way of the Sandwich Islands, Singapore, the Cape of Good Hope, and St. Helena, arriving in New York in June, 1842." As a result of his connection with the expedition he published the Reports on Geology, Crustacea, and Zoophyta, and spent in all thirteen years editing and superintending the printed reports resulting from these voyages. In 1855 he succeeded to the Chair of Mineralogy at Yale, a position he held till 1894, when he resigned. His "Manual of Geology" appeared in 1863, a fourth edition having been issued only this

year. He was part editor of the American Journal of Science from 1846, and continued his interest in it up to the last.

Dana received the Copley Medal from the Royal Society in 1877, and the Wollaston Medal from the Geological Society in 1872; he was a member of the Academy of Sciences, Paris, and of the Academies of Berlin and Munich, and was elected a Foreign Member of the Royal Society in 1884 and of the Geological Society in 1851.

His publications amount to nearly 400 in number, and when one considers that these include such colossal works as his "Mineralogy" and his "Manual" and "Text-Book of Geology," one is astonished at Prof. Dana's wonderful power of work, and are not surprised to learn that his health broke down upon several occasions owing to his excessive mental labours. It is wonderful and touching to read of Prof. Dana working on at the new edition of his "Manual of Geology" at the age of eighty-two, and being actively assisted in all his literary labours by his life-long companion with never-failing and watchful care to the end.

It is impossible to do justice to this distinguished man and personal friend in so short a notice, but we feel that, with our American brethren, we have also lost one of the greatest figures in geology of our time.

THE MARQUIS OF SAPORTA.

BORN 1823. DIED JANUARY 26TH, 1895.

BY the death of the Marquis of Saporta the sciences of Geology and Botany have suffered a severe loss. A wide botanical knowledge, combined with a vigorous enthusiasm and an untiring energy, enabled Saporta to add a rich store of facts to palæontological literature. Born at Saint-Zacharie (Var) in 1823, he spent some time in a Jesuit college at Fribourg, and in 1861, in conjunction with M. Matheron, published his first paper on a palæobotanical subject.[1] From that date up to the time of his death, Saporta devoted himself as a keen student to the problems of his chosen science.

His earlier works dealt especially with the Tertiary vegetation of the South-east of France; the floras of Aix, Manosque, Sézanne, and other localities have formed the subjects of elaborate monographs, in which he has not merely recorded lists of fossil species, but has dealt with the facts from a broad and philosophic standpoint. Between the years 1872–91 there appeared the splendid series of volumes on the Jurassic Flora of France; this comprehensive work, with its numerous illustrations and exhaustive text, forms an indispensable handbook to students of Mesozoic Botany. Saporta's most recent work, on Upper Jurassic and Lower Cretaceous Plants, appeared a few months before his death[2]; it contains a detailed geological and botanical analysis of an exceedingly interesting flora, and supplies fresh facts of considerable importance towards a more complete knowledge of the early history of dicotyledonous plants.

[1] Examen analytique des flores tertiaires de Provence.

[2] Flore fossile du Portugal (Direction des travaux géologiques du Portugal), Lisbon, 1894.

In addition to his numerous papers on palæobotany, Saporta has left such works as "Le monde des plantes avant l'apparition de l'homme,"[1] "Origine paléontologique des arbres cultivés ou utilisés par l'homme,"[2] and, in collaboration with Professor Marion, "L'évolution du règne végétal"[3]: these form fitting memorials of his wide knowledge as a palæobotanist, and of his zealous advocacy of the importance of fossil forms to the student of plant evolution. By some readers Saporta is perhaps best known as the too eager upholder of the claims of certain structureless casts and impressions to be included among fossil algæ. The valuable contributions to this subject by Nathorst have clearly shown how little weight must be attached to any speculations as to the development of plant life based on Saporta's "Algues fossiles"[4] or his "Organismes problématiques."[5]

As a contributor to Tertiary and Mesozoic Botany, Saporta's name will always be associated with that of Heer and Ettingshausen; and the younger generation of workers in this branch of palæontology may well look upon him as a worthy pupil of Adolphe Brongniart, whose philosophic spirit and scientific handling of facts are reflected in the writings of his younger countryman. The writer of a recent obituary notice in a French scientific journal has thus happily expressed Saporta's unfailing industry: "A des travaux considérables succédaient des entreprises plus considérables encore, et l'on oubliait l'âge en voyant l'œuvre s'augmenter et les horizons s'étendre toujours." A. C. S.

THE REV. NORMAN GLASS.

BORN DECEMBER 4TH, 1832. DIED DECEMBER 2ND, 1893.

THE death of the Rev. Norman Glass on the 2nd December, 1893, at his residence, 26, Lower King Street, Blackpool, has, we regret to say, hitherto escaped the attention of geologists. From local sources we learn that Mr. Glass was educated at the Western Congregational College, Plymouth, where, after distinguishing himself in logic and rhetoric, he entered upon a ministerial career, holding, in rotation, pastorates at Cardiff, London, Basingstoke, Rothwell, Wolverhampton, and Bilston. Soon after obtaining his last appointment he was obliged to retire from the ministry on account of failing health. He then removed to Manchester, and for a time occupied the post of Curator at the Queen's Park Museum.

From an early period Mr. Glass was keenly devoted to geology, and appears to have been on friendly terms with both Murchison and Owen, the former recognizing him as the discoverer of a patch of Silurian rocks (Wenlock Limestone) rising up through the Old Red Sandstone at Pen-y-lan, near Cardiff. He was also fortunate in finding in the Upper Chalk of Charlton, Kent, a new

[1] Paris, 1879.
[2] Paris, 1888.
[3] Paris, 1881–1885 (3 vols.)
[4] A propos des algues fossiles, 1882.
[5] Les organismes problématiques des anciennes mers, 1884.

genus of echinoid, which the late Dr. S. P. Woodward described and figured under the name of *Echinothuria floris* ("Geologist," 1863, pl. xviii, fig. B, pp. 327–330). But it was in his association with the late Dr. Thomas Davidson that Mr. Glass will be more particularly remembered by palæontologists. He had devised a method whereby the delicate calcareous internal structures of many of the Palæozoic Brachiopod shells could be exposed for examination, and although this was effected by a somewhat simple process through the agency of a knife, hydrochloric acid, and running water, it required the greatest patience, and no small amount of skill, before satisfactory results could be attained. These investigations naturally led to most important discoveries, and required Davidson to amend much of his earlier work. In the following terms Davidson thus alludes to the valuable assistance rendered him by Mr. Glass: "Prominent in this difficult study [the spiral-bearing Brachiopoda] has been the Rev. Norman Glass, to whose indefatigable perseverance and consummate skill I am indebted for the possibility of laying before my readers a large amount of positive and most valuable information. I can find no words sufficiently expressive to convey the gratitude I feel towards him for the unrelaxing energy he has displayed during upwards of three years in this difficult kind of investigation" [quotation from Davidson's Monograph]. Some forms of spiral-bearing Brachiopods had previously been subjected to development by Young and Neilson of Glasgow, Zugmayer of Vienna, and Whitfield of America, but the success attained by Mr. Glass seems to have eclipsed that of all others in this special branch of palæontological work. His specimens were generously presented to Dr. Davidson, who elaborately figured and described them in his great monograph on the "British Fossil Brachiopoda," published by the Palæontographical Society between 1880 and 1884, subsequently bequeathing them to the British Museum, where they are now exhibited among the type specimens of the "Davidson Collection."

As a further proof of his appreciation of these signal services to his subject, Davidson founded the generic name of *Glassia* to include such forms as *Atrypa obovata*, J. de C. Sowerby, the spiral structure of which, after exposure by Mr. Glass, was proved to be essentially different from that of any previously known genus.

In 1882 the Council of the Geological Society of London awarded him a moiety of the "Lyell Donation Fund" for "valuable aid and services rendered in elucidating the history and internal structure of the British and foreign Brachiopoda." Mr. Glass has contributed the following papers to geological science:—

(1) Silurian Strata near Cardiff. *Geologist*, 1861, vol. iv, p. 168.
(2) On the Development of the Spirals and their Connections in the Palæozoic Brachiopoda, in Davidson's "Monograph of British Fossil Brachiopoda," *Palæontographical Society*, 1882, vol. v, pp. 86–91.
(3) On a new form of Spiral in *Spirifera glabra*. GEOLOGICAL MAGAZINE, 1890, pp. 461–463.
(4) On *Athyris lævisculа*, Sow., sp., with the full disclosure of its loop, etc. *Ibid.* 1891, pp. 495–498.
(5) The Rocks on the Blackpool Coast. *Blackpool Times* (undated).
(6) The Local Geology of Blackpool. *Ibid.* 1893.

R. B. N.